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# BRIGHTNESS CONSTANCY IN SCHIZOPHRENIC ILLNESS

by

GARY W. DEAN

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "Brightness Constancy in Schizophrenic Illness" submitted by Gary W. Dean in partial fulfilment of the requirements for the degree of Master of Arts.

## ABSTRACT

The purpose of this study was to investigate brightness constancy in schizophrenic patients. Two schizophrenic groups, one chronic and one acute, and three control groups, non-schizophrenic psychiatric patients, hospitalized tuberculous patients, and normal volunteers from the hospital staff were used as subjects. The Brunswik and Thouless ratios were used as the index of constancy and matches were made by the subjects on a differential color mixer.

It has been suggested that brightness constancy is really a special case of brightness contrast. This possibility was discussed and it was concluded that most brightness constancy effects can be accounted for by contrast mechanisms. However since it has been demonstrated that constancy can be obtained in situations where contrast is inoperable, it is very likely that there may be additional central mechanisms operating in constancy. It was further concluded that these mechanisms operating in brightness constancy are more primitive than those operating in size, shape, and distance constancies.

Since many studies (e.g. Lovinger 1956, Weckowicz 1964) have reported reduced size, shape, and distance constancies in schizophrenic patients it was predicted that brightness constancy would also be reduced in schizophrenic illness. The results provided no confirmation for the prediction. Schizophrenic patients apparently do not differ significantly

from control groups in brightness constancy. However the results do suggest responses of schizophrenic patients may be significantly more variable than controls in this situation.

It was also found that schizophrenic patients tended to mix significantly more white color when making their matches of the standard and variable discs under the reduction screen condition. Possible causes of this unexpected behavior were considered.

In the discussion of the results an attempt was made to explain the possible reason why brightness constancy is not affected in schizophrenic patients while size, shape, and distance constancies are reduced. After reviewing the pertinent evidence, it was suggested that brightness constancy is based on more primitive perceptual mechanisms than those in size, shape and distance constancies and therefore is not disturbed in schizophrenic illness.

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# INTRODUCTION

Until recently there has been relatively limited interest in the relation of basic perceptual processes (e.g. dark adaptation, thresholds, and constancy phenomena) to schizophrenic illness. This was largely due to the early research reports of Kraepelin confirmed by Bleuler's clinical observations. According to Bleuler (1950, p. 58), Kraepelin concluded that "there are no perceptual changes in dementia praecox". Bleuler (1950) soon afterwards gave support to Kraepelin's rather dogmatic statement by reporting that there is a general absence of perceptual disturbances. excluding hallucinations, in schizophrenic patients. It has been pointed out that some German psychiatrists tend to differentiate between "true hallucinations" and "pseudo-hallucinations", (Jaspers 1963, p. 68). "True hallucinations" are supposed to have sensory character while "pseudo-hallucinations" have the character of vivid imagery. According to Mayer Gross (1955, p. 239) many authors (Schilder 1920, C. Schneider 1925, Schroeder 1925) deny the sensory nature of schizophrenic hallucinations and consider them rather as "pseudo-hallucinations". According to Bleuler schizophrenic patients have a "clear sensorium". These statements were incorporated into most textbooks of psychiatry and served to de-emphasize the importance of this area of research.

However the past two decades have witnessed a renewed interest

in the study of perception in schizophrenic and other psychiatric patients. As research accumulated it became increasingly apparent that perception may afford a valuable approach to the study of personality. Perception has acquired a much wider connotation, and has come to denote those processes classified by Wundt as apperception (cognition). This broadening of the concept of perception gave impetus to the "New Look" movement in perceptual research, which tried to understand perceptual processes in terms of personality "dynamics". At the same time Phenomenological and Existential schools in psychiatry (Arieti 1959, p. 48) became interested in the perceived or "experienced" world of mental patients. Together the two trends have led to a renewal of interest in all aspects of perception in the mentally disturbed, including basic perceptual processes such as constancy of perception.

Constancy of perception is a tendency to perceive an object as being constant despite changes in the proximal stimulus pattern due to variations in the conditions under which the object is perceived. Constancy phenomena apply to such aspects of perception as size, shape, distance, movement, brightness, and color. As a man walks away from an observer the image at the observer's retina becomes smaller, yet within certain limits he does not perceive the man as being smaller but as being of the same size at a greater distance. This is size constancy. In shape constancy one perceives for example a circular object as circular even if the image cast on the retina is elliptical. In distance constancy,

a standard physical unit of distance, for example one yard, subtends progressively smaller visual angles as the viewing distance of this particular object increases but these standard units are perceived as being the same length. Movement constancy enables one to perceive accurately the speed of objects in the environment despite the fact that far objects move across the visual field relatively more slowly than do nearer objects. Brightness constancy enables an observer to make judgments more in terms of the albedo of an object rather than the physical luminance of an object. Without brightness constancy a white house, for example, would grow progressively brighter as the sun comes up and progressively darker as the sun goes down. Color constancy enables one to perceive the "true" color of an object even though it may be placed in a different colored illumination. For example, blue paper in yellow light looks blue not gray as laws of color mixture would predict. Thus constancy of perception is one of the basic mechanisms of adjustment to the environment. It allows us to see stable objects in the external world despite an ever changing flux of stimulation. It holds the environment within wide limits constant. Without constancy the world would be unordered, confusing and unpredictable.

The possibility of constancy changes in schizophrenic patients has been examined in a number of studies. These have mainly dealt with size constancy and have compared schizophrenic and normal

populations in relation to this phenomenon. The results have been inconsistent. Some studies demonstrated no difference between schizophrenic patients and normals (Pishkin, Smith and Leibowitz 1962, Leibowitz and Pishkin 1961). "Overconstancy" among schizophrenic patients as compared to normals has been found in other studies (Raush 1951, Sanders and Pacht 1952, Pere 1961). Several other investigators have reported reduced size constancy in schizophrenic patients (Lovinger 1956, Crookes 1957, Weckowicz 1957, Hamilton 1963). However Weckowicz restricted his conclusions to chronic schizophrenic patients, mainly of the hebephrenic type with personality deterioration, since Raush (1951) found size constancy in well preserved paranoid patients to be higher than in normal controls. Weckowicz also found increased intra-subject variance in size constancy of schizophrenic patients. Weckowicz and Blewett (1959) later showed that there is a positive correlation between poor size constancy and impaired ability for abstract thinking in schizophrenic patients. They postulated the same mechanism of "selectivity" underlying concept formation and size constancy. Weckowicz, Hall and Sommer (1958) reported a positive correlation between the impairment of size and distance constancies in their sample of schizophrenic patients. Weckowicz (1964) in a further study reported that shape constancy is also impaired in schizophrenic patients.

Those studies finding impaired constancy of perception support

the hypothesis that the schizophrenic "break" with reality is related to impairment of complex perceptual mechanisms. According to Lovinger (1956) schizophrenic patients who clinically are described as being in poor contact with reality may be perceptually in poor contact with the surrounding world. McReynold's (1960) presents a theory closely related to this point of view. He postulates a breakdown of basic perceptual mechanisms which prevents the continuing assimilation of incoming stimuli into the conceptual schema of the organism The resulting build up of unassimilable percepts gives rise to a great deal of anxiety. According to McReynolds, schizophrenic behavior is an attempt to reduce this anxiety. Weckowicz (1964) has suggested that the breadkown in constancy of perception may be interpreted in terms of McReynolds' theory as a failure of the percepts to be assimilated into the perceptual schema. This causes a "strangeness" of the perceived world giving rise to the anxiety responsible for many of the behavior anomalies which are observed in schizophrenic patients. In the studies with results suggesting "overconstancy" of perception in schizophrenic patients a hypothesis was offered that patients experiencing a loss of contact with reality overcompensate for this loss. Those studies that found no constancy differences between schizophrenic patients and normals supported such theorists as Bleuler who held that the schizophrenic illness was due to an "associative" thought disturbance and did not involve basic perceptual processes.

The conflicting results of previous investigators suggest that the general question is open to further research. No research has been done on brightness constancy in relation to schizophrenic illness. The purpose of this study was to investigate brightness constancy in schizophrenic patients as one possible factor responsible for the distortion of perception in these subjects.

There is some evidence that brightness constancy is based on different mechanisms than those involved in size, shape, and distance constancies. The latter three depend on the size and shape of the retinal image in relation to the distance and slant cues of the normal field, whereas brightness constancy depends on the ratio between the amount of light reflected by the object and the amount reflected by the surrounding background. Size, shape, and distance constancies involve perception of specific geometric patterns, whereas brightness constancy does not.

Some investigators (Wallach 1948, Wallach and Galloway 1946) even maintain that brightness constancy is really a contrast phenomenon occurring in special circumstances. The relationship described by Osgood (1953, p. 280) is as follows. If a neutral gray test patch is viewed against a black surround it appears brighter than when viewed against a white surround - this is brightness contrast. When the surround of a test surface is obviously in shadow, the test surface appears relatively brighter than when the surround is illuminated. This is known as brightness constancy and can be interpreted as "taking account of" the field

illumination. If one ignores the illumination and deals directly with differential stimulation of retinal regions then the laws of contrast appear to be sufficient. If brightness constancy is the same as contrast, then size, shape, and distance constancies are more likely to depend on central mechanisms (associative elaboration) than is brightness constancy, because it is commonly believed that contrast can be accounted for with minimum reference to central mechanisms outside the retina and visual projection system. Wallach and Galloway (1946) and Wallach (1948), have demonstrated the equivalence of contrast and brightness constancy under certain artificial conditions. Wallach points out however, that the contrast effect occurs only if the surround (inducing field) borders on the test surface. However MacLeod (1932), Vernon (1937), and Hsia (1943) have all reported that constancy effects can be obtained even though the conditions necessary for contrast have been eliminated. Hsia removed contrast by setting the discs alone far in front of a black background. MacLeod and Vernon achieved the same result by making the backgrounds for each disc equal to one another. That is the two backgrounds would have appeared equally bright had they been viewed through a reduction screen. Also there are large individual differences in constancy phenomena that are not obtained in contrast experiments (Vernon 1952). Finally Landauer (1964) reports that constancy can be manipulated by suggestion and changes in instruction. Contrast effects cannot be similarly changed. Thus some investigators feel that both

phenomena are based on the same peripheral mechanisms but other investigators feel they are based on different mechanisms. Perhaps the safest conclusion would be that most brightness constancy effects can be accounted for by contrast mechanisms. However since it has been demonstrated that constancy can be obtained in situations where contrast is inoperable, it is very likely that there may be additional central mechanisms operating in constancy.

## Hypothesis

In recent years several investigators have reported a deficit in perceptual size, shape, and distance in schizophrenic patients. This research suggests that these patients may be suffering from an impairment of basic perceptual mechanisms. However no research on brightness constancy in schizophrenic patients has been reported. On the basis of the previous discussion the following hypothesis was put forward:

Brightness constancy in schizophrenic patients is lower than in normal controls and non-schizophrenic psychiatric patients.

## METHOD

### The samples

Five groups of subjects were used: thirty chronic schizophrenic patients, thirty acute schizophrenic patients, thirty non-schizophrenic psychiatric patients, thirty normal controls, and fourteen hospitalized tuberculous patients[1]. Thus there were two schizophrenic groups (one chronic and one acute) and three control groups. The non-schizophrenic psychiatric group was included in order to find out whether reduced brightness constancy was specifically related to schizophrenic illness or occurred also in other psychiatric conditions. The tuberculous group was included to exclude the possible effect of hospitalization on brightness constancy. All subjects were male.

The schizophrenic group included only patients in whom the diagnosis of schizophrenia had been firmly established by psychiatrists who had examined them. Chronic patients were differentiated from the acutes on the basis of the duration of their stay in hospital. Patients hospitalized more than one year were considered to be chronic. Those hospitalized less than one year were considered to be acute. To insure that none of the chronic subjects was recovered but institutionalized, it

1. It was not possible to obtain more than fourteen patients from the sanatorium. All other patients were either too sick or too infectious to be taken out of the hospital.

was necessary to review the case histories and then interview each potential subject. This work was done with the help of a psychiatrist.[1] Those patients who did not reveal hallucinations or active thought disorder, for example, delusions, bizzare ideas, talking past the point, weak and illogical associative flow, etc., or who otherwise did not show any active schizophrenic "process" during the interview were rejected. In the chronic group eight were diagnosed as simple, five as catatonic, five as hebephrenic, four as paranoid, and eight as undifferentiated schizophrenics. The mean age of this group was 41 (range 24-65, S.D. 10.2) years. The median length of stay was ten years with a range of 1-32 years.

The acute group included three simple, three catatonic, and three paranoid schizophrenic patients. Seven others were diagnosed as schizophrenic reaction, and the remaining fourteen were diagnosed as undifferentiated schizophrenics. The diagnosis in these cases was made by the psychiatrist in charge. The mean age was 32.5 (range 17-58, S.D. 11.5) years. The median length of hospitalization was three weeks, ranging from three days to ten months (mean 7.8, S.D. 11.3 weeks).

The non-schizophrenic subjects were chosen on the basis of unanimous agreement among the medical staff in charge that the patient

1. The author is grateful to Dr. T. Weckowicz for screening the patients in this study.

was not schizophrenic. Included here were four patients diagnosed as psychopaths, fifteen as alcoholics, seven as cases of behavior disorder, two as inadequate personality, one as a drug addict, and one as a psychoneurotic. Their mean age was 36.8 (range 17-65, S.D. 11.5) years. Median length of hospitalization was four weeks ranging from one day to fourteen months (mean 8.6, S.D. 18.6 weeks).

No psychiatric patient undergoing insulin or shock treatment was included. Mental defectives and cases where organic brain pathology was suspected were similarly excluded. All patients except the acute schizophrenics were either not taking drugs or had been taken off them three days prior to testing. The medical staff did not permit the acute patients to be taken off drugs. However, the dosage in most cases was small.

The normal controls consisted of ward staff volunteers at the hospital. Their mean age was 33.6 (range 18-55, S.D. 9) years. Median length of employment was three years with a range of four months to twenty four years.

The tuberculous controls consisted of non-contagious volunteers from the Aberhart Sanatorium. Their mean age was 44.8 (range 18-65, S.D. 11) years. Their median length of stay was seven and one-half months ranging from one day to nineteen months.

It was not possible to match the groups exactly with regard to age. A simple analysis of variance of the ages showed they were

significantly different ($p < .01$). However, if the means of the schizophrenic groups were averaged against the means of the controls they were very close (36.7 and 38.4 respectively) and not significantly different by t-test.

The samples could not be matched as to the length of hospitalization since there are very few long stay non-schizophrenic patients (excluding mental defectives and patients with organic brain damage) in the hospital. However, the length of hospitalization of the acute schizophrenic patients was shorter than that of the non-schizophrenic patients, although this difference using t-test was not statistically significant. Thus the duration of hospitalization was controlled, at least in the acute schizophrenic group.

As stated before all subjects in this study were male. While it would have been desirable to test both males and females it was not possible to obtain an equal number of them in each group. Using unbalanced samples in this respect did not seem justifiable since Schooler (1963) concluded that theories based on experimental findings with one sex in chronic schizophrenia cannot be generalized to explain the behavior of chronic schizophrenic patients of the other sex. Male subjects were more numerous than females and therefore were used. Thus all results of this study apply to males only.

Apparatus

A differential color mixer was used. It consisted of a plywood box which was divided into two compartments each of which was 13" long, 12.5" wide and 18" high. The interior of each compartment was painted a standard glossy white. Through the rear wall of the box two electrically driven shafts protruded 1/2" into each compartment. Flat black and flat white cardboard discs[1] of diameter 7 3/4" were mounted on both shafts in such a way that they interlocked. When the discs were turning at a speed of 3000 rpm the resulting perception was that of two homogeneous gray surfaces corresponding to each disc which differed in brightness. The disc in the compartment on the subject's left was made the standard. The proportion of white and black in this disc was the same throughout the experiment. Of the total 360 degrees, a 315 degree segment was white and the remaining 45 degree segment was black. On the subject's right was the variable color mixer. The variable color mixer permitted the subject to change the relative amount of black and white of the two interlocking discs while they rotated, by turning a handle. Each turn of the handle moved the white disc through a 20 degree arc. Total range of movement in the dics was 277 degrees with a maximum white setting of 337 degrees and a minimum white setting of 60 degrees.

1. The reflectance of the black and white discs was judged by an experienced photographer to be .20 and .90 respectively.

To attain the conditions necessary for brightness constancy the two wheels were illuminated by two different light intensities. The illumination of the standard disc was provided by a standard 100 watt bulb that was connected to a General Electric variac. The variac allowed the voltage to be manipulated. It was necessary to use higher voltage than the normal 110 volts because bulbs under high voltage burn with a whiter light and have a smaller proportion of the light waves from the red end of the visual spectrum. This instrument (set at 130 volts throughout the experiment) helped to overcome the problem of color bias inherent in all artificial lighting. Without this arrangement it was impossible to match the two discs in whiteness because the standard was always more reddish than the variable disc. Light from the 100 watt bulb was reflected onto the disc from a flat white wall, a distance of 3 feet, 3 inches. The illumination of the variable disc consisted of the light provided by four clear 150 watt bulbs burning at 110 volts. This light was also reflected from the wall to the disc, a distance of 5 feet, 5 inches.

The subject viewed the apparatus while seated in a chair. The chair was fixed so that the eyes of the subject were always approximately 3 feet to 3 feet 6 inches from the discs.

There were two conditions under which the subject was allowed to view the discs. The first condition, the no-screen condition, permitted the subject to view the apparatus with an unrestricted view of the two

discs. A photograph of the apparatus under this condition is shown in figure 1. Under condition two, the reduction screen condition, the subject's view of the surface of the white-gray revolving discs was greatly reduced. A white removable plywood reduction screen of dimensions 24 inches by 18 inches was placed in position 12 inches from the front of the discs. Two tubes of diameter 3/4 inch were so affixed that the subject could view only a small portion of each revolving disc. The tubes were placed 6 inches apart forcing the subject to move his head slightly to view first the standard and then the variable or vice versa (the two discs could not be viewed simultaneously). This condition effectively destroyed constancy of perception. A photograph of the apparatus with the reduction screen in place is presented in figure 2.

The room had no window and the outside light was excluded. Its dimensions were 12 feet by 9 feet 9 inches, by 8 feet 6 inches. It was painted entirely flat white (reflectance .85) in order to prevent color biasing of the target black and white discs. The table on which the apparatus rested was covered with a white sheet to serve the same purpose. In addition to the illumination discussed before, a 150 watt ceiling light was placed directly above the mid-point of the apparatus so that it would equally illuminate each disc of the apparatus.

The luminance (i.e. light reflected) of the discs as measured by a General Electric lightmeter was twenty and fifty-two foot candles

for the standard and variable discs respectively. This measurement was taken when the discs both contained 315 degrees white. Of course the luminance of the variable disc would change proportionately as the black-white ratio in this disc was varied by the subject. It was also established that under the different illumination conditions the variable disc reflected an amount of light equal to the standard, when it had 135 degrees of white. Therefore the two discs, when under different illuminations, with 135 degrees white in the variable disc and 315 degrees in the standard, appeared equally bright under the reduction screen condition.

A white curtain 24 inches long and 18 inches wide was constructed to prevent the subject from seeing the discs when they were stopped. It was simply held manually in front of the discs at the appropriate times.

## Experimental procedure

The task of the subjects was simply to match the whiteness of the variable disc with that of the standard. There were three different conditions under which this matching was done.

Condition one: Matching with an unrestricted view of the discs, with no reduction screen, each disc being under a different standard illumination. (This is referred to as the no-screen condition.)

Condition two: Matching with a much reduced view of the discs,

that is with the reduction screen, each disc being under a different standard illumination. (This is referred to as the screen condition.)

Condition three: Matching with an unrestricted view of the discs, each disc being under equal illumination.

The dependent variable in all cases was the adjustment of the variable disc, measured in terms of the number of degrees of white color mixed by the subject in attempting to match the standard.

Each subject made four separate continuous matches under condition one and a similar number under condition two. After each match the discs were stopped and the number of the degrees of white on the variable disc was recorded. The curtain arrangement, described in the section on the apparatus was held in front of the discs by the experimenter as the wheels were stopped at the end of each trial. This effectively prevented the subject from seeing the discs when they were stopped.

All subjects were given two final trials under condition three. In this case they were asked to match the discs when both discs were under equal illumination. This procedure was included as a control for lack of co-operation, poor eyesight, or inability to follow instructions.

In each condition half the matches were descending (i.e. the variable disc at the start had more white than the standard disc) and half were ascending (i.e. less white at the start in the variable disc

than in the standard). The sequence was always the same. First a descending match, then an ascending match, then a descending match, and so on. Thus possible errors of anticipation and habituation were controlled.

A further consideration was the order effect. There was always a possibility that the presentation of condition one, followed by condition two would produce different results than the reverse order of presentation. This was controlled for by assigning half of the subjects of each group to the first order (condition one followed by condition two), and the other half to the second order (condition two then condition one).

If a subject was assigned to order one he was given the following instructions: "Come in . . . please sit down and observe the two revolving discs in front of you. Notice that they differ in whiteness. You can change this difference by turning this handle. I want you to make this disc (the experimenter pointed to the variable disc) . . . look the same as that disc . . . (the experimenter pointed to the standard) . . . so that they are of equal whiteness." At this point the experimenter demonstrated how to change the proportion of white and black in the variable disc and said: "Simply make them look alike in whiteness. Are there any questions? Go ahead. Let me know when you feel they are the same." Four separate matchings were then obtained. The reduction screen was then put up and the following instruction was given: "Now look through these two holes which you see in front of you. Can you see two gray

patches that are different? One is darker than the other. Now I want you to do the same thing as before. I want you to make this one ... (the experimenter pointed to the variable disc) ... look like that one ... (the experimenter pointed to the standard) ... so that they are alike in whiteness." The experimenter carried out the demonstration again and said: "Go ahead. Let me know when you feel they are the same in whiteness." Four matches were then obtained. Finally two additional trials under the no-screen condition and equal illumination were carried out.

If a subject was assigned to order two he received the following instructions: "Come in, please sit down and look through these two holes which you see in front of you. Can you see two gray patches that are different? One is darker than the other. You can change this difference by turning this handle." The experimenter demonstrated how to do it and said: "I want you to make this one ... (the experimenter pointed to the variable disc) ... look like that one ... (the experimenter pointed to the standard disc) ... so that they are of equal whiteness. Make them look alike in whiteness. Are there any questions? Go ahead. Let me know when you feel they are the same." Four separate matches were then obtained. Then the screen was removed and the following instructions given: "Now I want you to do the same thing as before. Simply make the two discs you see look alike in whiteness by turning the handle. Let me know when they are the same in whiteness."

Four matches were made. Two additional trials under equal illumination then followed.

The method of average error was used throughout the experiment, with the subject making the adjustments of the variable disc after being instructed by the experimenter. Subjects from all groups were tested in random sequence to control for "apparatus decay".

Method of calculating brightness constancy

According to Leibowitz (1956) it is convenient to describe data from experiments on perceived size, shape, and brightness with reference to predictions based on the "law" of object constancy and the "law" of the retinal image. The retinal image "law" predicts responses which are in accord with variation in the geometrical properties of the retinal image. The constancy "law" predicts responses corresponding to the physical properties of the object independent of the specific retinal image pattern. Experimental data seldom conform to either "law" but rather represent a compromise between the tendencies toward object constancy and the retinal image. The Brunswik ratio is frequently used to indicate the extent to which experimental data are in accord with these theoretical limits and is expressed by the following formula:

$$\text{Brunswik ratio} = \frac{R - S}{C - S}$$

where

R = A measure of the subject's response under no-screen condition.

S = Prediction in terms of the law of the retinal image, in this case the subject's response under the screen condition.

C = Prediction in terms of object constancy, in this case a setting of 315 degrees white on the variable disc.

This ratio multiplied by 100 gives a percentage value of the extent to which the data are in accord with the constancy law. A Brunswik ratio of 1.00 indicates complete agreement. A ratio of zero signifies a complete absence of constancy. Thouless (1931) has criticized this ratio on the ground that since the sensory effects of light vary according to the logarithm of the intensity (Fechner's law), the values for R, S, and C should first be transformed into a log scale.

$$\text{Thouless ratio} = \frac{\log R - \log S}{\log C - \log S}$$

Thouless felt that this ratio would give more correct results. An analysis using both ratios was decided upon since the superiority of one ratio over the other has not been firmly established.

## Experimental design

The data lends itself to two forms of analysis of variance. Analysis of variance one: A two by five[1] factorial analysis of the obtained

1. A two by four analysis with the TB group omitted was also carried out in cases where the variances were not homogeneous.

Brunswik and Thouless ratios was carried out. The two factors were: the order effect, at two levels (no-screen then screen or screen then no-screen) and the group effect at five levels. Statistically the prediction is that the mean ratios (either Brunswik or Thouless) of the schizophrenic patients will be less than the ratios of the controls.

Analysis of variance two: It is also possible to analyze the no-screen and screen matching without converting them into a ratio. This approach enables the relationship between "no-screen" and "screen" conditions on the one hand, and the groups on the other, to be analyzed. The design which best fits the data for this purpose consists of four two by two latin squares each replicated fifteen times. Each latin square is assigned to one of the four groups (the TB group was omitted from this analysis since the design demands equal n's in each group). Variables in the latin square are: Order of treatment presentation, and periods. Partialing out the periods effect controls statistically for the possibility that scores obtained on the first four matchings may be different from the scores made on the second four matchings independent of whether the screen or no-screen presentation is involved. This effect is not controlled for in the two by five factorial analysis. Treatments are balanced within the latin square. It was predicted that the difference between the no-screen and the screen matches would be less in the schizophrenic than in the control groups, which meant that there would be an interaction between the groups and treatment conditions (no-screen, screen). It

was tacitly implied that the groups would not differ appreciably under the screen condition because no constancy was involved in this case. Therefore it was also predicted that the schizophrenic patients would mix less white than the controls under the no-screen condition.

## RESULTS

Preliminary analysis of the data indicated that the variance is homogenous for the two by four factorial analysis of the Brunswik ratios, but the variances for both the two by four analyses of the Thouless ratios and the latin square analysis were found to be heterogeneous. The arcsin transformation is often found to stabilize variances when the data is in the form of ratios. This transformation was carried out on the Thouless ratios but the variances remained heterogeneous. However Box (1953) has emphasized that since the F test is very insensitive to non-normalities, and since with equal n's it is also insensitive to variance inequalities it would be best to accept the fact that it can be safely used under most conditions. Therefore, the results of the analysis of variance in this experiment were considered valid.

Analysis of variance one: As can be seen from Table 1 the mean Brunswik ratios for the various groups were not significantly different.[1] The mean group ratios were as follows: Chronic Schizophrenic Patients (CS): .59; Acute Schizophrenic Patients (AS): .62; Non-Schizophrenic Patients (NSP): .61; Staff Controls: .58; Tuberculous Controls (TB): .65.

1. This analysis was based on the adjustment for unequal n's recommended by Winer (1962 p. 292).

TABLE 1

Summary of Analysis of Variance of Brunswik Ratios
2 X 5 Factorial Design unequal n's
(Ascending and Descending series combined)

| Source | df | MS | F |
|---|---|---|---|
| Order (A) | 1 | 888.0 | 3.45 |
| Groups (B) | 4 | 169.7 | - |
| A X B | 4 | 216.7 | - |
| Residual | 124 | 257.1 | |
| Total | 133 | | |

However it should be noted that the order effect was very close to being significant at the .05 level. See figure 3[1] for a graphical presentation of these results. To clarify the meaning of this finding, since matches under the descending and ascending series conditions may be different perceptual tasks, the Brunswik ratios for both the descending and ascending series were calculated. The means for ascending and descending series are presented graphically in figures four and five respectively. In both cases very similar results to those based on the combined ascending and descending series were obtained. None of the

1. These graphs are presented only for the convenience of the reader. It should be noted that the shape of the lines in the graph is irrelevant. The relationship between the magnitudes represented by the points in the graphs is important. This relationship would remain the same with any order of presentation of the points. The particular order of presentation, which is not relevant from the point of view of the hypotheses being tested, was chosen because in a sense a continuum of "schizophrenicity" can be assumed stretching from normals at one end to chronic schizophrenic patients at the other.

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effects was significant although the order effect was close to the .05 level. A summary analysis of both the ascending and descending Brunswik ratios is presented in Appendix B. The group means are included. However in the ascending series three chronic and two acute schizophrenic patients had Brunswik ratios equal to zero. (These subjects are identified in Appendix A as CS12, CS111, CS29, AS29, and AS215.) In the descending series one chronic and four acute schizophrenic patients were also found to have zero Brunswik ratios. (These subjects are identified in Appendix A as CS111, AS21, AS28, AS29, and AS210.) These results are difficult to explain because the zero ratios resulted from an average score under the screen condition which was higher than the no-screen condition. That is, these subjects mixed more white color with the reduction screen than without it. No subject in any of the control groups recorded similar results. It must be concluded that some uncontrolled factor was determining the responses of these subjects. Certainly impaired constancy is not involved since the zero ratios are due to the screen matches, a condition which is designed to destroy constancy. Thus the responses of these subjects were considered to be invalid. The ascending and descending Brunswik ratios were reanalyzed with these aberrant cases omitted. The elimination of these subjects caused the near significant order effect to disappear in both the ascending and descending series. The group effect remained unchanged. The respective means for ascending and

descending series are presented graphically in figures 6 and 7 respectively. A summary of the reanalyzed data for ascending and descending series appears in Appendix C. The group means are included.

Thouless ratios, in case that they might more accurately represent the data, were also calculated and analyzed in fashion similar to the Brunswik ratios. The 2 X 5 factorial analysis of the Thouless ratios is presented below in Table 2. The mean Thouless ratios were as follows: CS .66, AS .69, NSP .695, Staff .672, TB .72.

In this analysis the order effect is significant at the .05 level, although the differences between groups remained non-significant. To ensure that no group means differed significantly from each other a multiple comparisons test[1] was also carried out. No significant differences were found. A summary of this analysis is presented in Appendix D. The mean Thouless ratios are presented graphically in figure 8.

Thouless ratios were not calculated for ascending and descending series responses. However it is very likely that an explanation similar to the one presented above to explain the order effect in the Brunswik ratios also applies here even though the means for order one and two in

1. Duncan's new multiple range test with Krammer adjustment for unequal n's.

the TB group are rather different. This difference may be due to the low n in this group, i.e. poor sampling. Reanalysis of the Thouless ratios with the TB group omitted removed the order effect. This analysis is summarized in Appendix E.

TABLE 2

Summary Analysis of Variance of the Thouless Ratios
Ascending and Descending series combined with
the TB Group included

| Source | df | MS | F |
|---|---|---|---|
| Order (A) | 1 | 1146.0 | 4.74* |
| Groups (B) | 4 | 285.2 | 1.18 |
| A X B | 4 | 119.7 | - |
| Residual | 124 | 241.8 | |
| Total | 133 | | |

* $p \leq .05$

The Thouless ratios after arcsin transformation also produced a significant order effect, but as before, no significant group differences. The mean arcsin ratios together with a summary of this analysis are presented in Appendix F. Thus in all three cases (Brunswik, Thouless, or arcsin ratios) the results did not indicate any significant differences among the groups in their mean constancy scores.

The hypothesis that brightness constancy in schizophrenic patients is less than in normals and non-schizophrenic patients was not confirmed. In all three cases the order effect was significant or close to significance with the aberrant cases included and non-significant if these cases were

omitted, in both ascending and descending series analyses.

A simple one-way analysis of variance of the chronic schizophrenic group to determine if any differences existed among the diagnostic sub-groups (simple, catatonic, hebephrenic, paranoid, and undifferentiated), produced no significant differences. This analysis together with the mean Brunswik ratios for each diagnostic sub-group is presented in Appendix G. The paranoid group mean was the median of the five sub-groups. Raush (1951) reported that paranoid schizophrenic patients had higher size constancy ratios then non-paranoid schizophrenic patients. In brightness constancy there appears to be no difference between chronic schizophrenic diagnostic sub-groups.

Analysis two: In order to confirm the hypothesis of reduced brightness constancy in schizophrenia this analysis must show a significant groups by treatments interaction. However since it was assumed that the matching under the reduction screen condition would be the same in all the groups, it was expected that the significant interaction would be due primarily to lower response measures for the schizophrenic patients under the no-screen condition. Therefore the combined (screen plus no-screen) group means for the two schizophrenic groups could also be expected to be significantly lower than the controls. Table 3 summarizes the mean score for each group under each treatment (screen, no-screen) condition.

The mean score for each group under order one and order two

is presented, together with the mean score for each group under period one and period two, in Appendix H.

TABLE 3

Mean Score for each Group under each Treatment Condition

| | CS | AS | NSP | Staff |
|---|---|---|---|---|
| No-Screen | 255 | 255 | 249 | 244 |
| Screen | 159 | 151.6 | 141 | 140 |

The TB group, which included fewer subjects than the other groups, was omitted from this analysis since latin square designs require equal n's in all groups. Table 4 presents a complete summary of the latin square analysis of variance.

TABLE 4

Summary of Analysis of Variance Latin Square Design

| Source | df | MS | F |
|---|---|---|---|
| Order (0) | 1 | 4,455 | - |
| Groups (A) | 3 | 48,410 | 4.05** |
| A X O | 3 | 34,448 | 2.88* |
| Residual a | 112 | 11,957 | |
| Periods | 1 | 3,301 | - |
| A X Treatments | 3 | 5,248 | - |
| A X Periods | 3 | 18,132 | 2.08 |
| Treatments | 1 | 10,083,540 | 1157.4**[1] |
| Residual b | 112 | 8,712 | |

* $p \leq .05$, ** $p \leq .01$

1. Much beyond the accepted level of significance (as was expected).

As can be seen from Table 4 the difference between groups is significant at the .01 level. The groups by orders interaction is also significant ($p < .05$). However the interaction of most interest, from the point of view of the tested hypothesis - the groups by treatments interaction - was not even close to statistical significance. The groups by treatments interaction is depicted graphically in figure 9, and the groups by orders interaction is presented in figure 10. The groups by periods interaction was not significant although it was close to the .05 level. It is presented in figure 11.

Orthogonal comparisons were made to see which of the mean differences were contributing to the significant group difference (screen no-screen combined). The following results were obtained. The difference between the chronic and acute patients was not significant. The difference between the schizophrenic group (chronics plus acutes) and the other groups was significant at the .01 level. No significant difference was found between the non-schizophrenic patients and the staff. Table 5 summarizes the analysis based on orthogonal comparisons.

TABLE 5

Multiple Comparisons of Group Settings
(screen, no-screen combined)

| | $S^2$ | A | F |
|---|---|---|---|
| Chronics versus acutes | 11,957 | 7,115 | - |
| Schizophrenics versus controls | 11,957 | 133,482 | 11.6** |
| NSP versus staff | 11,957 | 4,539 | - |

** $p < .01$

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Thus the significant group effect is mainly due to the difference between schizophrenic patients and the control groups. However figure 9 shows the schizophrenic patients to have higher means than the controls. In short the results, as far as the combined group means are concerned, are opposite to those predicted. The groups by treatments interaction although not significant is also opposite in direction to that predicted.

At this point it is not clear which treatment condition gave rise to the significant group difference between schizophrenic patients and controls. In order to clarify this point both the screen and no-screen matches were each subjected to a simple one-way analysis of variance. (The TB group was included in this case since a simple analysis of variance lends itself to unequal n's.)[1]

The means used in these two analyses are those presented in Table 3. It will be noted that the means of the chronic and acute schizophrenic patients are higher than those of the controls on both the screen and the no-screen conditions. There were no significant group differences in either the screen or no-screen analyses. However group differences under the screen condition approaches the significance at the .05 level. Therefore it is mainly the screen condition which makes the four groups significantly different (i.e. schizophrenic patients significantly different from non-schizophrenic patients) when the screen no-screen settings

1. The mean scores of the TB group under the no-screen and screen conditions were respectively 239 and 133.

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are combined. A summary of the screen and no-screen analyses is presented in Appendix I.

To understand more clearly why the schizophrenic patients mix more white under the screen condition, both the ascending and descending responses were analyzed. The same latin square design was used. Table 6 summarizes the results of the latin square analysis based on the ascending series, and Table 7 summarizes the results of the descending series.

TABLE 6

Summary Analysis of Variance
Latin Square Design
Ascending Series

| Source | df | MS | F |
|---|---|---|---|
| Order (O) | 1 | 86 | - |
| Groups (A) | 3 | 1054 | 1.06 |
| A X O | 3 | 587 | - |
| Residual a | 112 | 991 | |
| Periods | 1 | 104 | - |
| A X Treatments | 3 | 784 | - |
| A X Periods | 3 | 1522 | 1.64 |
| Treatments | 1 | 684802 | |
| Residual b | 112 | 930 | |

The mean scores for both the ascending and descending series, on groups by treatments, groups by orders, and groups by periods interactions are presented in Appendix J. The groups by treatments,

groups by orders, and groups by periods interactions, for both ascending and descending series, are shown in figures 12, 13 and 14 respectively.

TABLE 7

Summary Analysis of Variance
Latin Square Design
Descending Series

| Source | df | MS | F |
|---|---|---|---|
| Order (O) | 1 | 1139 | - |
| Groups (A) | 3 | 3793 | 3.12* |
| A X O | 3 | 4745 | 3.90** |
| Residual a | 112 | 1216 | |
| Periods | 1 | 2 | - |
| A X Treatments | 3 | 449 | - |
| A X Periods | 3 | 1714 | 2.16 |
| Treatments | 1 | 562117 | |
| Residual b | 112 | 792 | |

Analysis of the ascending series showed no significant findings, but analysis of the descending series showed groups effect to be significant at the .05 level, and a significant interaction between groups and orders ($p < .01$). Thus it appears that the significant findings with ascending and descending series combined are mainly due to the performance of the <u>schizophrenic</u> patients on the <u>screen</u> setting in the <u>descending</u> series. The tendency of schizophrenic patients to add significantly more white color, when making matches under the screen condition in the descending

series is further complicated by an interaction with order of treatment presentation. Chronics tended to make high white matches under order one, while the acutes did so under order two.

Inspection of the raw data shows that not all schizophrenic patients responded in this way. Those schizophrenic patients who did produce high white matches with the screen were in many cases the same subjects who obtained zero Brunswik ratios either on ascending or descending series. A screen matching that is higher than a no-screen matching is an invalid result (insofar as constancy is concerned). On this basis the eight subjects who had zero Brunswik ratios were omitted and the data was reanalyzed. It will be noted that the results of the analysis under descending series are almost identical with results of the analysis of variance of the combined ascending and descending series. Since no significant differences occur in the latin square analysis of the ascending series, the adjustments resulting from the omission of the aberrant cases were made on the combined ascending and descending series data. The discussion will be restricted to the combined series analysis. However it should be remembered that the significant findings in the combined latin square analysis are mainly attributable to the responses of the schizophrenic patients in the descending series, under the screen condition.

No reanalysis of the data is possible since the latin square design does not lend itself to data with unequal n's. Thus the inter-

pretation of the data with the aberrant cases omitted must rest on inspection of the adjusted means. Table 8 presents the adjusted means for each group under no-screen and screen conditions.

TABLE 8

Adjusted Means for each Group Under No-Screen and Screen Conditions

| | CS | AS | NSP | Staff |
|---|---|---|---|---|
| No-screen | 258 | 251 | 249 | 244 |
| Screen | 155 | 137 | 141 | 140 |

The adjusted means for each group under order one and order two, and for each group under period one and period two are presented in Appendix H. The groups by treatments, groups by orders, and groups by periods interactions are presented graphically in figures 15, 16, and 17 respectively.

Inspection of figures 15, 16, and 17 shows that the means for the acute schizophrenic patients are now no different from those of the controls. The chronic schizophrenic patients, however, remain relatively high on the screen condition (see figure 15). Figure 16 shows that the high white matching was made by the schizophrenic group under order one. If only the responses of the chronic schizophrenic patients under order two are examined it will be found that their means are quite close to those of the three other groups. In order to determine to what extent the results of the simple analysis of variance of group

mean matches under the screen condition were influenced by these aberrant cases another simple analysis of variance was carried out with the scores of these patients omitted. A summary of this analysis is presented in Appendix I (3). This analysis shows that the differences between the group means are not significant, but there is a tendency ($p < 0.1$) to mix more white that is in the same direction as that found in the previous analysis in which the aberrant cases were included. However the significance of this tendency for the schizophrenic patients to mix more white color than the controls is reduced from being short of the 0.05 level to being just short of the 0.1 level. The significant groups by orders interaction of the previous analysis (see Table 4 and figure 9) is most likely eliminated through the omission of the eight aberrant cases. Similarly the near significant groups by periods interaction (see Table 4 and figure 11) is much reduced.

Thus to summarize, the groups effect and the group by order interaction were found to be significant in both the combined analysis and the descending series analysis, and in both cases the significance of these results is mainly attributable to the responses of a few subjects under the screen condition, in the descending series. The omission from the analysis of the data of a few aberrant subjects renders all the differences nonsignificant, although there still remains a tendency for schizophrenic subjects to mix more white color than the controls while making matches under the screen condition. The possible explanations

of this finding will be presented in the discussion.

The analysis of matches under the no-screen with equal illumination showed no significant group differences. Presumably co-operation, understanding of instructions, and good eyesight were controlled for, at least under the no-screen condition. The means (in degrees white) for each group were as follows: CS 319, AS 322, NSP 323, Staff 319, TB 320. A summary of this analysis is presented in Appendix I (4).

Since high intra-subject variance was reported in size constancy of schizophrenic patients by Weckowicz (1957) and since many of the schizophrenic patients in the present study appeared to be highly variable in their responses especially under the screen condition, a final analysis comparing intra-subject variability was undertaken. The same latin square design was used. Two variances per subject were computed. One based on the four screen responses, the other based on the four responses with no reduction screen. These intra-subject variances were used as the scores of the subjects in the analysis of variance. The results are summarized in Table 9.

Table 10 presents the mean intra-subject variances for each group under the no-screen and screen conditions. Table 11 summarizes the mean intra-subject variances for each group under order one and order two, and Table 12 summarizes the mean intra-subject variances for each group under period one and period two.

TABLE 9

Analysis of Variance of the Intra-Subject Variances - Latin Square Design

| | | | |
|---|---|---|---|
| Groups (A) | 3 | 25,466,866 | 7.76** |
| Order (O) | 1 | 972 | - |
| A X O | 3 | 21,656,603 | 6.60** |
| Residual a | 112 | 3,281,297 | |
| Periods | 1 | 1,013,350 | - |
| A X treatments | 3 | 11,783,051 | 3.618* |
| A X periods | 3 | 16,661,434 | 5.116** |
| Treatments | 1 | 53,947,839 | 16.560** |
| Residual b | 112 | 3,256,504 | |

* $p < .05$
** $p < .01$

TABLE 10

Mean Intra-Subject Variances for each Group Under Screen and No-Screen Conditions

| | CS | AS | NSP | Staff |
|---|---|---|---|---|
| No-screen | 712 | 455 | 242 | 179 |
| Screen | 2212 | 2360 | 432 | 377 |

TABLE 11

Mean Intra-Subject Variances for each Group Under Order One and Order Two

| | CS | AS | NSP | Staff |
|---|---|---|---|---|
| Order one | 2172 | 649 | 327 | 328 |
| Order two | 751 | 2166 | 348 | 228 |

TABLE 12

Mean Intra-Subject Variances for each Group
Under Period One and Period Two

| | CS | AS | NSP | Staff |
|---|---|---|---|---|
| Period one | 957 | 2175 | 388 | 224 |
| Period two | 1967 | 640 | 287 | 332 |

The mean intra-subject variances presented in Tables 10, 11, and 12 are graphically illustrated in figures 18, 19, and 20 respectively. As can be seen from Table 9 neither the order nor the periods effects was significant, but the groups by treatment interaction was significant at the .05 level. The difference between groups (no-screen, screen conditions combined), the groups by order interaction, and the groups by periods interaction were all significant at the .01 level. However inspection of the individual intra-subject variances (screen condition) revealed that in four cases (two chronics and two acutes) the variance results were extremely high. (These cases are identified in Appendix A as CS11, CS118, AS21, and AS210.) For example in the acute group (order two) the total group sum of intra-subject variances was 58,295. With the two cases omitted the sum was reduced to 24,242. Two scores accounted for more than half the total which was based on fifteen cases. If these cases are omitted the data are rendered much more meaningful, even though the unequal n's do not allow an actual recalculation. The adjusted intra-subject variance means for the groups by treatment,

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groups by order, and groups by periods interactions are presented in Tables 13, 14, and 15 respectively.

TABLE 13

Adjusted Intra-Subject Variance Means for each Group Under No-Screen and Screen Conditions

| | CS | AS | NSP | Staff |
|---|---|---|---|---|
| No-screen | 712 | 455 | 242 | 179 |
| Screen | 1498 | 1225 | 432 | 377 |

TABLE 14

Adjusted Intra-Subject Variance Means for each Group Under Order One and Order Two

| | CS | AS | NSP | Staff |
|---|---|---|---|---|
| Order one | 1458 | 649 | 327 | 328 |
| Order two | 751 | 1031 | 348 | 228 |

TABLE 15

Adjusted Intra-Subject Variance Means for each Group Under Period One and Period Two

| | CS | AS | NSP | Staff |
|---|---|---|---|---|
| Period one | 957 | 1040 | 388 | 224 |
| Period two | 1253 | 640 | 287 | 332 |

The adjusted mean intra-subject variances presented in Tables 13, 14 and 15 are included in figures 18, 19, and 20 respectively. On the basis of graphical inspection it appears that the significant groups

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by treatments interaction remains (see figure 18), but the groups by orders and groups by periods interactions largely disappear (see figures 19 and 20). One conclusion that may be drawn from this analysis is that schizophrenic patients are significantly more variable in their behavior on matching tasks than are non-schizophrenic patients and normal controls, and since the groups by treatments interaction is significant it may be assumed with a high degree of probability that their brightness constancy as measured by Brunswik and Thouless ratios would also be more variable.

## DISCUSSION

Thus the hypothesis of this study was not confirmed. Tendencies toward brightness constancy were not significantly less in schizophrenic patients than in control groups. This is true whether the conclusions are based on analysis one or analysis two. It should be stressed that the elimination of the doubtful cases in no way affects the conclusions above. The subjects were omitted to help clarify the meaning of the unexpected results. Elimination of these cases occurred after the main calculations were completed. However the analysis of the intra-subject variances showed that although schizophrenic patients do not differ from controls in brightness constancy they may be significantly more variable than controls in their ability to maintain brightness constancy. This finding is in agreement with the finding of Weckowicz (1957) who showed that the estimation of size constancy was also more variable in schizophrenic patients than controls.

The tendency of the schizophrenic patients to mix more white color than the controls under the screen condition in the descending series is an unexpected result. It should be clear that the responses under the no-screen condition provide the actual test for constancy of perception. The screen condition effectively destroys constancy. Therefore there can be no relationship of these findings to brightness constancy. Several hypotheses to explain the tendency of these patients

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to add more white color than the controls when matching a gray standard under the reduction screen condition will now be considered. These hypotheses are post hoc explanations and they are proferred here only tentatively.

One could consider, for example, the possibility that perseverative tendencies could account for the tendency of the schizophrenic patients to mix more white color under the screen condition. In the group of schizophrenic patients who made their matchings under the screen condition, after first matching under the no-screen condition, the results could be explained in terms of perseveration, the subjects tending to mix as much white under the screen condition as under the no-screen condition. However this perseveration hypothesis cannot account for the facts that schizophrenic subjects who made matches under the screen condition first, also tended to mix more white color than the controls, although the hypothesis is tenable if applied to the data after the aberrant cases have been removed (see figure 16).

Motivation, affecting the amount of effort in making the adjustment was also considered, especially as a possible explanation for the finding that this difference in the matching tended to occur only on the descending series. In the descending series approximately eight turns of the handle were required to obtain a veridical match while in the ascending series approximately four turns of the handle were sufficient to obtain the same result. Although insufficient evidence is available

it is suggested that the greater effort required was perhaps one factor responsible for the tendency of schizophrenic patients to mix too high a percentage of white under the screen condition. This possibility is given support by such theorists as Huston and Shakow (1946) and Cohen (1956) who theorize that the most basic deficit on cognitive tasks in schizophrenic patients is motivational.

It is also possible that the matching under the screen condition is a task which requires a more abstract attitude than the matching under no-screen condition. In one sense it is a more artificial set up and is divorced from ordinary life situations in which one deals with concrete colored objects and not patches of color perceived through narrow tubes. Katz (1935) points out that ordinary surfaces present colors, "surface colors", colors that seem to be part of an object, but when a visual area is viewed in the absence of co-existing objects the color that is seen is "film color", an unlocalizable "substanceless" color. Furthermore memory is involved in this situation since the subject could not look through both tubes at the same time.

If we grant for the moment that this condition of the experiment required a more abstract attitude in order to concentrate on these film colors we could expect more variable results under this condition. This in fact was the general case since both the schizophrenic patients and controls had higher intra-subject variances on the screen relative to the no-screen condition. Furthermore, we could expect even higher

intra-subject variances in the schizophrenic subjects since they are known to be handicapped on abstract tasks relative to normal controls. The schizophrenic subjects, in the present study, showed indeed a higher intra-subject variability. Thus to say that the screen condition was more abstract could explain some extreme aberrant responses, but this still does not explain their general tendency for mixing a high percentage of white in this situation. However if it is accepted that matching under the screen condition is more difficult it may also be regarded as being a more ambiguous task. An ambiguous situation is known to render perception more autistic especially in schizophrenic patients. The subject's perception is more influenced by his values, needs, and emotions which may distort his perceptions and bias his judgment. It is therefore possible that the schizophrenic patients, instead of making a veridical match on the basis of light intensity at the retina made non-veridical matches because they based on the symbolic idiosyncratic meaning of the stimulus. White for instance may mean "good" and therefore be a much more preferable stimulus than black which to the subject may mean "bad" and therefore a stimulus to be avoided. This hypothesis is given partial support by Raush (1956) who reports that symbolic value has greater influence on size judgments made by schizophrenic patients than on those made by controls. Another study by Pishkin, Smith and Leibowitz (1962) also is relevant in this connection. Their results support the hypothesis that it is the symbolic

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or emotional value of the stimulus which accounts for schizophrenic deficit on many perceptual tasks. Weckowicz and Blewett (1959) present evidence that the schizophrenic patient is less able to attend selectively, and consequently performs more poorly on many different types of task. The deficit in selecting and attending may be the result of distraction due to autistic fantasies and complexes. However one would have to show that this behavior is not completely idiosyncratic and that schizophrenic patients as a group tend to overvalue white and undervalue black before this hypothesis could be tenable.[1]

An adaptation hypothesis could also be considered. This hypothesis explains the tendency to mix more white as being due to a positive time error. A positive time error occurs in consecutive brightness matchings when the match is made on the basis of a memory image of the standard. The brightness of the variable stimulus tends to be underestimated and more white mixed, because of the sensory adaptation which took place while the subject was examining the standard stimulus. The condition of the experiment was such that the subject could not view both patches simultaneously. He was forced to view one and then the other. It is therefore feasible that some subjects made consecutive matchings first looking at the standard and then making the match based on the memory image. It is also quite possible that

1. Since white color is more highly valued in our culture than black this hypothesis is quite feasible.

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brightness adaptation occurred more rapidly in schizophrenic patients, particularly in the chronic group, than in the controls. Further research to substantiate this hypothesis is necessary.

No reasonable explanation, apart from the fact that a few aberrant cases were mainly involved, can be provided for the groups by order interaction. In some way the order of treatment presentation differentially affected the behavior of the chronic and acute schizophrenic patients. The close to significance groups by periods interaction actually arises because of the order effect. Removal of the aberrant cases caused these interactions to disappear. Whatever the explanation for these two interactions may be, their contributing variance was partialled out of the analysis and did not affect the calculation of the major effects, (i. e. the groups effect, and the groups by treatments interaction) in the latin square design.

We now turn to discuss the theoretical implications of our findings that brightness constancy remains unaffected in schizophrenic illness, although the responses of schizophrenic patients are more variable than controls in this situation. In the introduction section of this paper the possibility of brightness constancy being similar to contrast phenomena was discussed and it was concluded on the basis of available evidence that most brightness constancy effects can be accounted for by contrast mechanisms, although in certain cases additional central mechanisms may be operating in constancy. If it is

true that brightness constancy and brightness contrast are due to the same basic peripheral mechanisms - reciprocal inhibition of retinal regions - this might account for the failure to confirm the predictions of this study. Brightness constancy is not reduced in schizophrenia because its operation may depend on mechanisms which are less complex than those responsible for size, shape, and distance constancies. However, even if brightness constancy cannot be equated with contrast phenomena and therefore explained on the basis of the visual peripheral and projective mechanisms there is a great deal of evidence that the mechanisms responsible for brightness constancy are phylogenetically and ontogenetically more primitive than those responsible for size, shape, and distance constancies.

To begin with, it was pointed out in the introduction section that brightness constancy depends on the ratios of the light reflected between test object and the field in which it is viewed, whereas, size, shape, and distance constancies depend on pattern vision which is necessary for the perception of texture gradients (Gibson 1950). Further evidence is supplied by the fact that in the earlier stages of evolution the eye has no cornea or lens and cannot furnish a picture of objects, although it enables the organism to make simple discriminations based on light intensity. An important mechanism underlying depth perception in human organisms and therefore size, shape, and distance constancies is the stereoscopic vision which in the course of phylogenesis develops

most extensively in primates (Clark 1959). Therefore these constancies depend on evolutionary higher mechanisms than brightness constancy. Similar evidence is provided by Lashley (1937) using rats, and Klüver (1942) using monkeys. They have shown that problems involving simple brightness discriminations can be relearned after removal of both occipital lobes. However the same does not apply to the relearning of simple geometric pattern (shape) discriminations thus showing that simple brightness discriminations can be handled by sub-cortical brain centers whereas patterned discriminations cannot be attained without the visual cortex. Hebb (1949) discussed the report that men born blind later acquiring sight by surgery had great difficulty learning pattern discriminations although the ability to distinguish figure from ground seemed to operate independent of learning. Since the distinction of figure from ground requires the ability to differentiate illumination intensity in the field, it follows that the mechanisms regulating illumination intensity discriminations are more primitive than those regulating pattern discrimination. According to Osgood (1953, p. 277) research has been carried out to determine whether constancy operates more or less strongly in the more primitive perceptual processes of children than in the more highly developed and critical perception of adults. A simple matching task was used and in general it was found that four-year old children match grays in about the same way as do adults. These results agree with a study by Katz (1935). He used a

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large number of subjects ranging in ages from three years to adulthood, and was unable to find an age in which brightness constancy was absent. However Woodworth and Schlosberg (1954, p. 433) report that Burslaff (1931) using revolving black and white discs, did not find poorer constancy in children than in adults, although the performance of both adults and children was generally lowered under this condition. Thouless (1931) also reports a study which found brightness constancy increases with age. However studies reporting no changes in brightness constancy with age seem to outweigh those that do report changes. Contrary to the above findings most studies dealing with size constancy (e.g. Thouless 1931) agree in showing that size constancy increases with age. If this be so the evidence implies (although it is admittedly controversial) that learning is a factor in size, shape, and distance constancies but apparently is of minimal importance in brightness constancy. Leibowitz, Chinetti, and Sidowski (1956) measured size, shape, and brightness constancies as a function of exposure time. They reported that reduction of exposure time differentially affects the tendencies toward size, shape, and brightness constancies. Shape constancy is reduced, size constancy is unaffected, and brightness constancy is improved. If the same experimental procedure - for example reduction of exposure time - affects the three types of measures differentially, it follows that different

mechanisms may be involved. Since brightness constancy is improved by decreased exposure time the suggestion can be made that brightness constancy depends on more primitive perceptual mechanisms. This can be related to Buhler (reported in Woodworth and Schlosberg 1954, p. 432) who believes that visual perception is not instantaneous but rather involves a process. He states that response to the general illumination is more primitive than the perception of objects, and that the initial response to each new field of vision may be a registering of the general illumination.

Evidence referred to in this section that brightness constancy depends on lower cerebral mechanisms than size, shape, and distance constancies can be integrated with the hypothesis put forward by Weckowicz and Blewett (1959). Weckowicz and Blewett present a great deal of evidence that the perception of schizophrenic patients is generally more primitive, more global, less differentiated and structured, than that of normals. They suggest that these findings can be accounted for in terms of a "selectivity" theory of perception. Abnormalities of thinking and perception, including size constancy, are based on an inability to "attend selectively" or to select relevant information from the mass of information actually present in the environment. They further postulated that more primitive perceptual processes are influenced to a greater degree by "here and now" factors of the immediate situation

and to a lesser extent by the past experience. Therefore primitive perception is influenced to a greater extent by the perceptual field organization, such as described by the basic gestalt laws, (e.g. proximity, similarity, and good continuation) than is the more advanced perception which in its turn is more influenced by past experience, and therefore tends to be in terms of familiar meaningful objects situated in three dimensional space. The cues relating to "thingness" of the content of the perceptual field are attended selectively, while other cues are suppressed.

Complementing the "selectivity" theory of Weckowicz and Blewett is the work of the Leipzig school dealing with "Aktualgenese", of perception (Sander 1930). "Aktualgenese" is concerned with the emergence of percepts. According to the theory proposed by this school an act of perception is not instantaneous but develops through three organizational stages. It develops in milli-seconds from being global and undifferentiated to being precise and definite. According to Sander a most primordial feeling-like stage is followed by a second "geometric-ornamental" stage and eventually by a third "realistically meaningful" stage. For our present purposes only the second and third stages will be considered. The percept in the second geometric-ornamental stage can be described as tending toward symmetry, regularity, circularity, and good continuation - in accordance with the gestalt laws. It involves pure non-representational patterns. Perception

in this stage is relatively tied to the "here and now" aspects of the environment and independent of past experience or future considerations. Very little cognitive activity is involved in this stage. The third "realistically meaningful stage" involves more cognitive activity. It is said to be characterized by pressures toward representational organization in terms of palpable objects or "things". In this stage the percept becomes more differentiated, precise, meaningful, and less based on the concrete "here and now" features which characterized it in the second stage. The findings of Werner (1948) with children, brain damaged subjects, and schizophrenic patients, and Weckowicz and Blewett (1959) are relevant here. They have shown that the perception of schizophrenic patients tends to be more global and undifferentiated, and therefore shows a regression to a more primitive stage. In the terms of Sander's theory of perception schizophrenic patients may regress from the third to the second organizational stage. Each new developing percept tends to be arrested before it reaches the third stage, while in normal adults it carries on into the third stage where it receives cognitive elaboration resulting in the completion of "Aktualgenese". Arrested perception and restriction to the less differentiated geometric-ornamental stage results in the "here and now" character of perception in schizophrenic patients reported by Weckowicz and Blewett. Furthermore the inability of schizophrenic patients to advance their perception to the third "realistically meaningful"

stage may be connected with the selectivity theory of Weckowicz and Blewett, that is the ability to select the relevant environmental cues is a prerequisite to completion of "Aktualgenese". The finding of Leibowitz, Chinetti and Sidowski that brightness constancy in contrast to other constancies improves when the time of exposure is short acquires additional significance in view of the work of the "Aktualgenese" school. Brightness constancy may be more closely related to the second "geometric-ornamental" stage of perception while size, shape, and distance constancies may be part of the third "realistically meaningful" stage and be more concerned with the perception of familiar objects in three-dimensional space.

To conclude this discussion it may be stated that the presented evidence suggests the possibility that brightness constancy might not be reduced in schizophrenic patients because it depends on more primitive mechanisms than those responsible for size, shape, and distance constancies which apparently are reduced in these subjects.

## CONCLUSIONS

1. It has been found in the present study that brightness constancy as measured in this experiment is not reduced in schizophrenic patients.
2. It has also been found that brightness constancy shows increased variation in schizophrenic patients relative to control groups.
3. It is possible that the negative finding in regard to brightness constancy in the present study could be explained by more primitive mechanisms underlying brightness constancy than those responsible for size, shape, and distance constancies, which were found to be reduced in schizophrenic patients in some of the other studies.

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# FIGURES

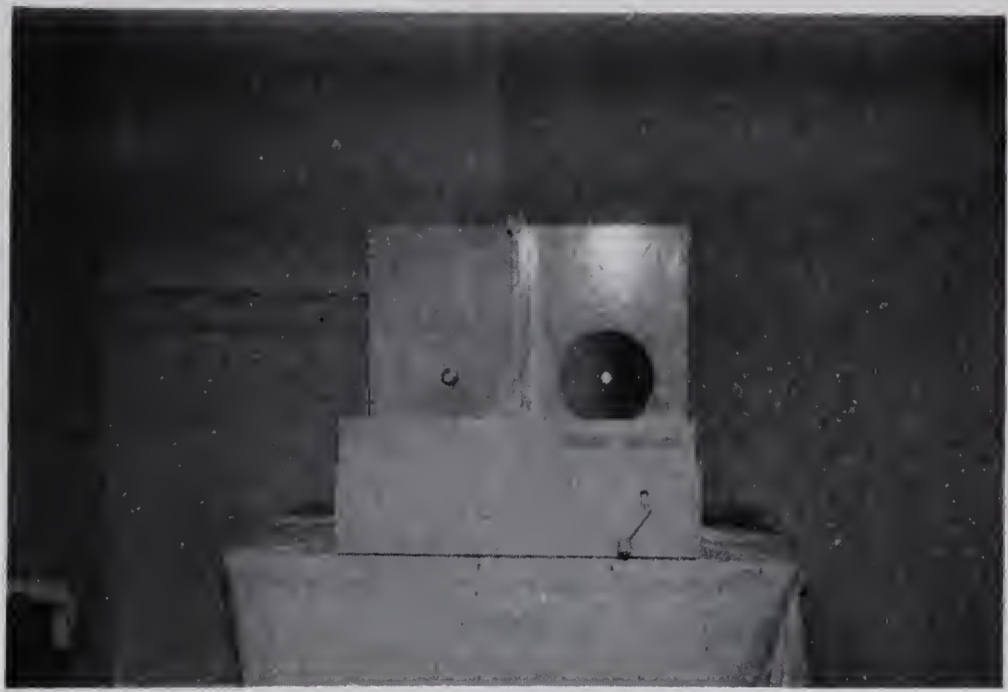

Figure 1. Photograph of apparatus, no-reduction screen condition.

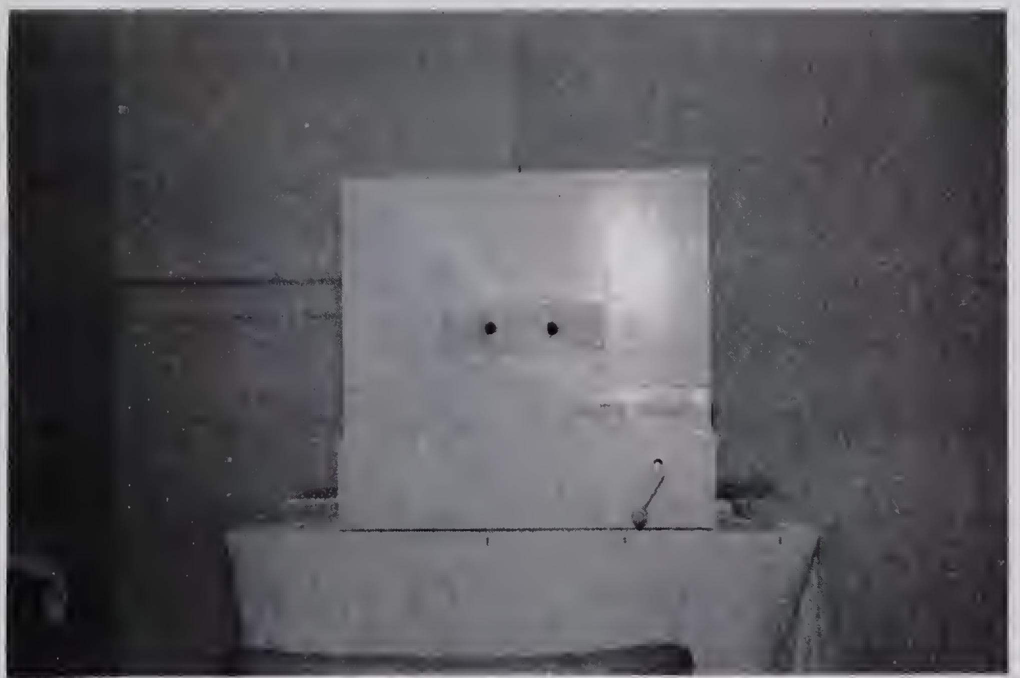

Figure 2. Photograph of apparatus, reduction screen condition.

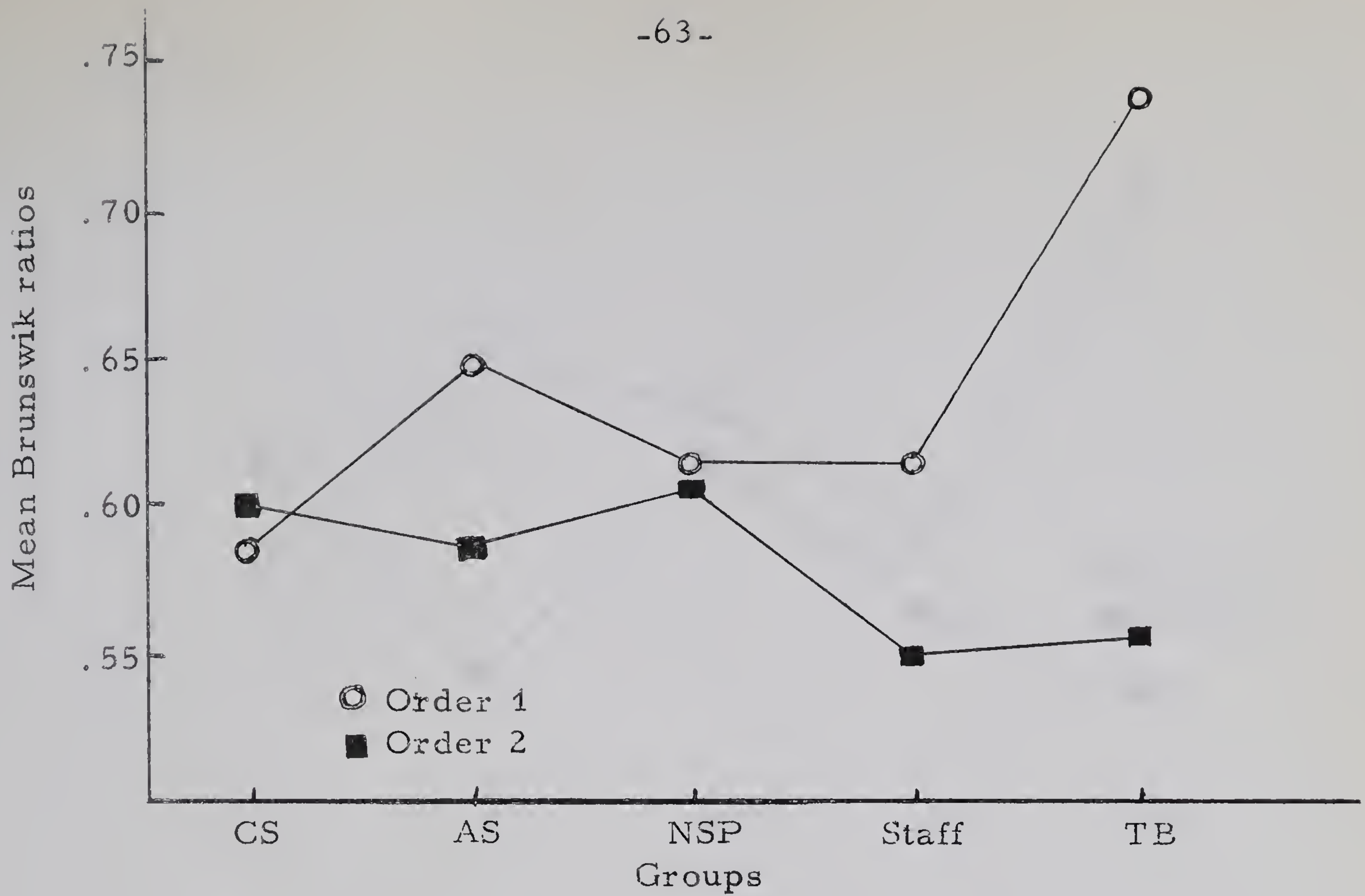


Fig. 3. Mean Brunswik ratios for each group under order 1 and order 2.

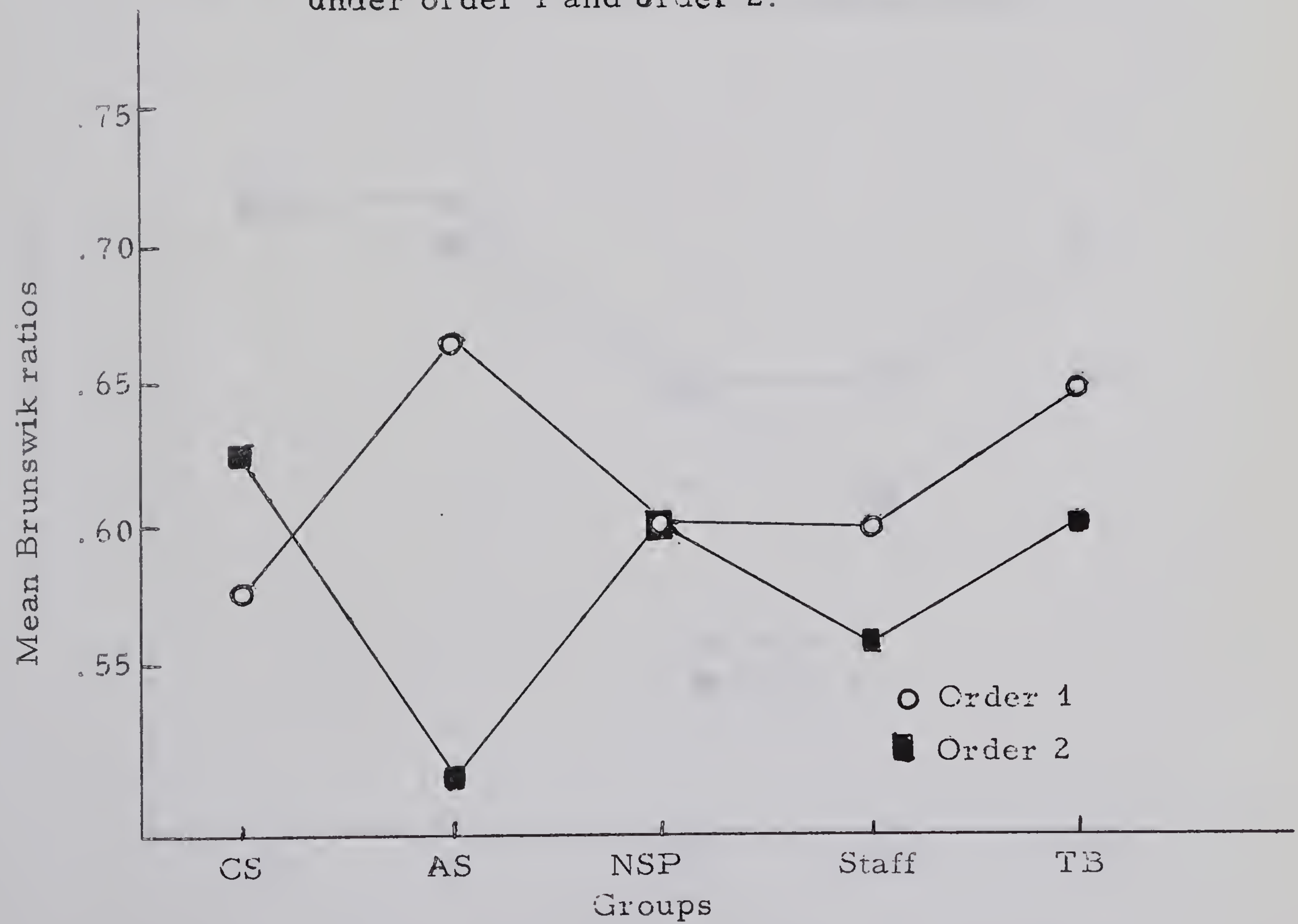


Fig. 4. Mean Brunswik ratios for each group under order 1 and order 2. Ascending series.

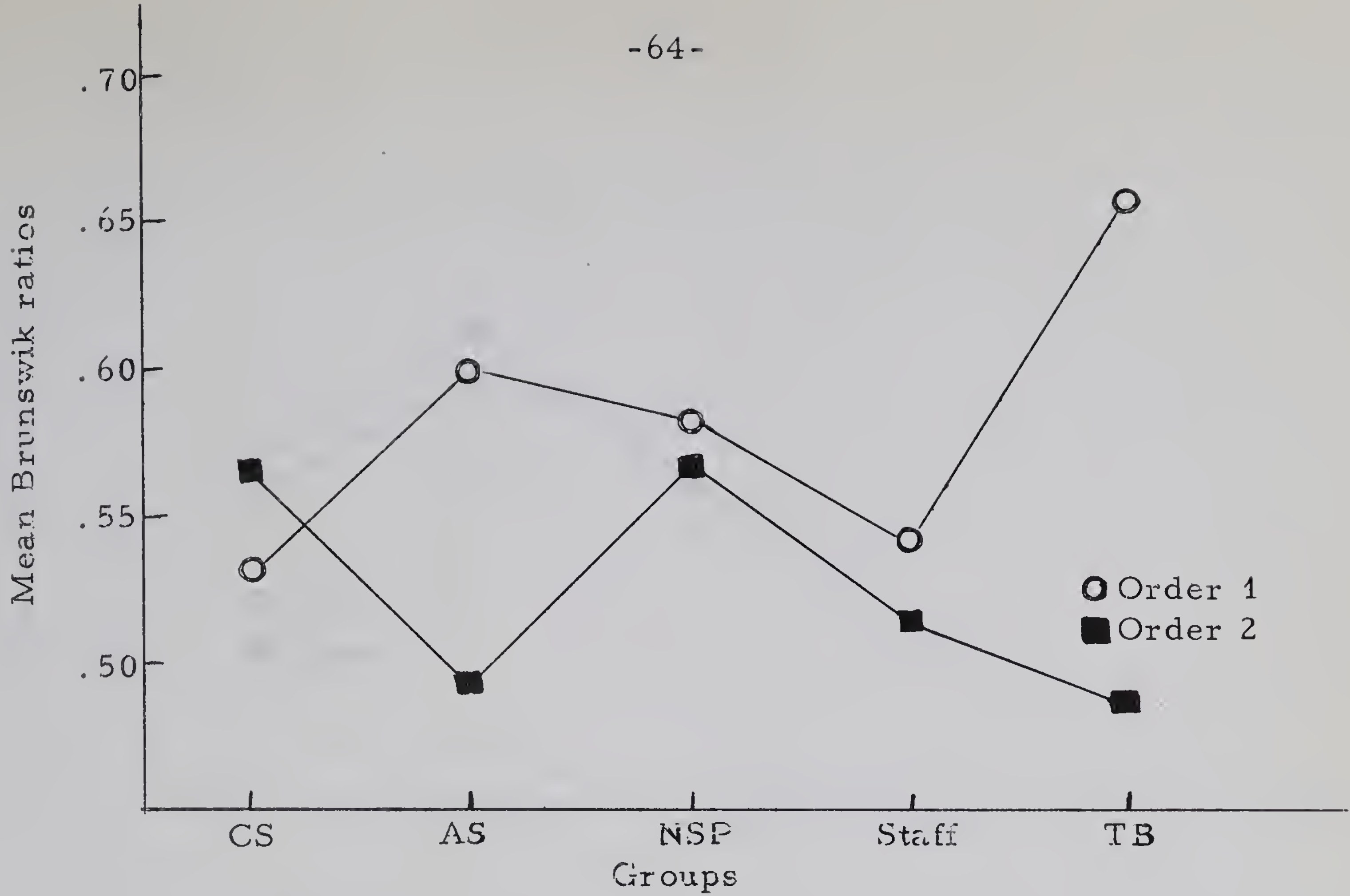


Fig. 5. Mean Brunswik ratios for each group under order 1 and order 2. Descending series.

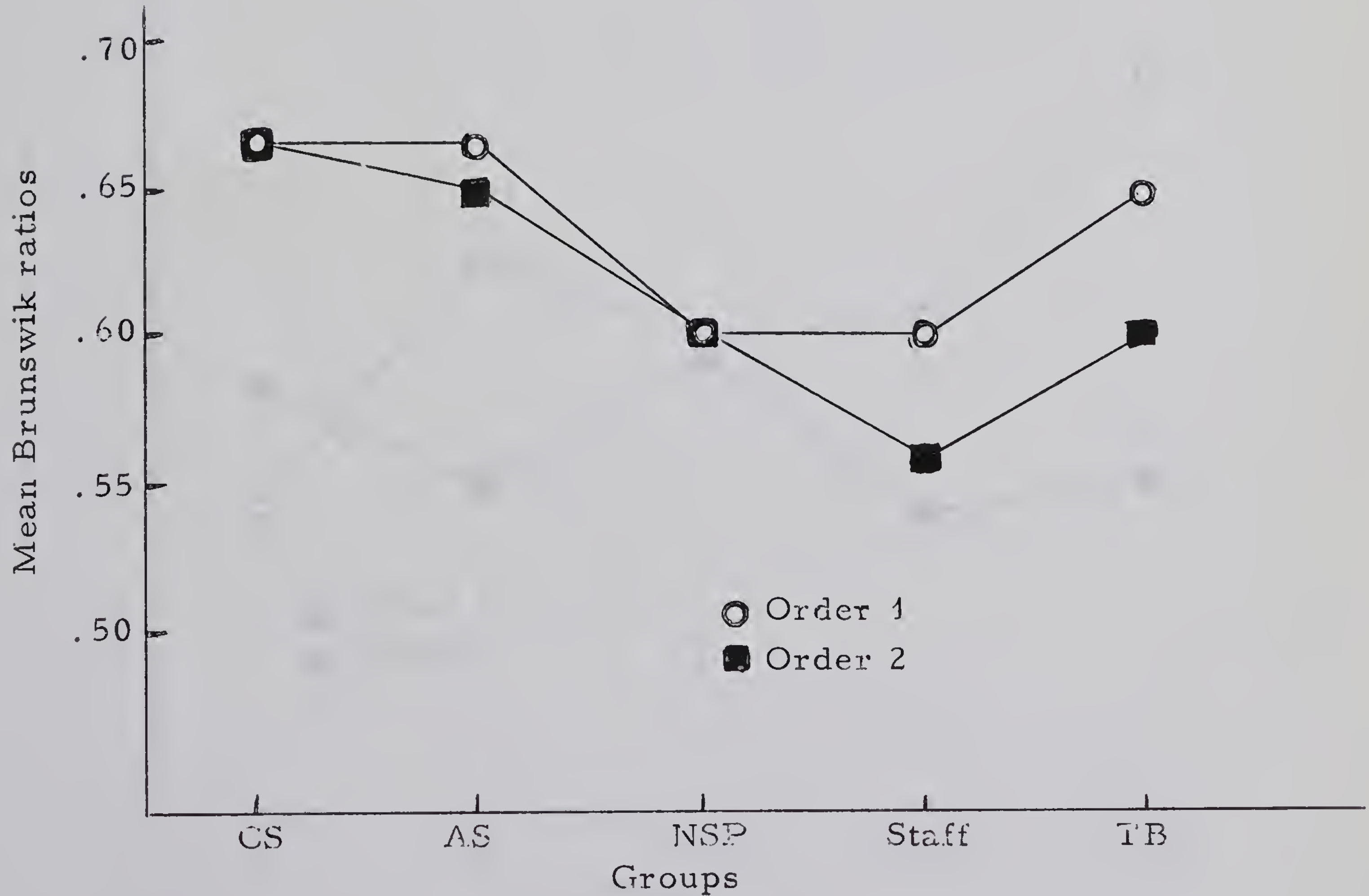


Fig. 6. Adjusted mean Brunswik ratios for each group under order 1 and order 2. Ascending series.

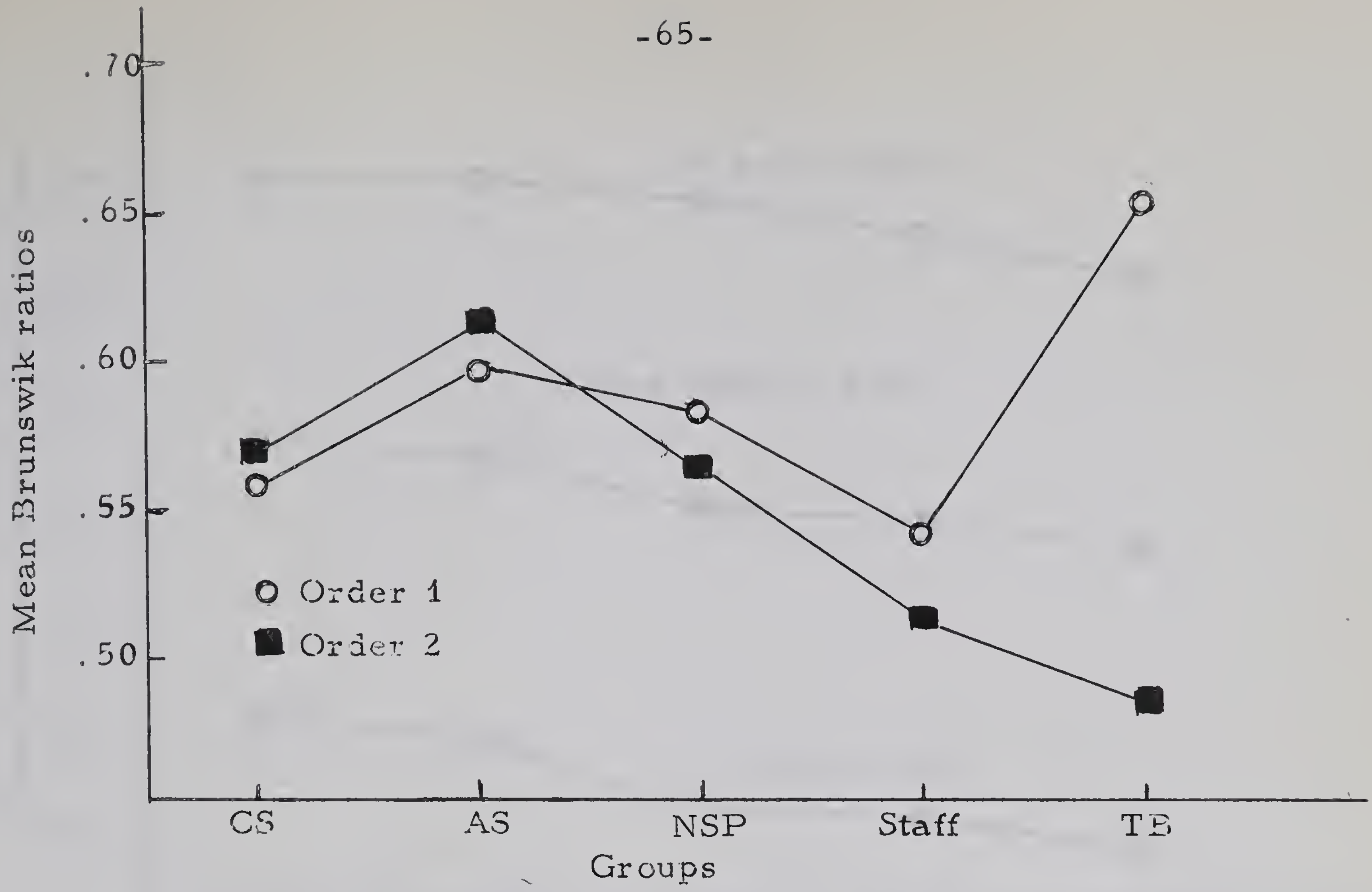


Fig. 7. Adjusted mean Brunswik ratios for each group under order 1 and order 2. Descending series.

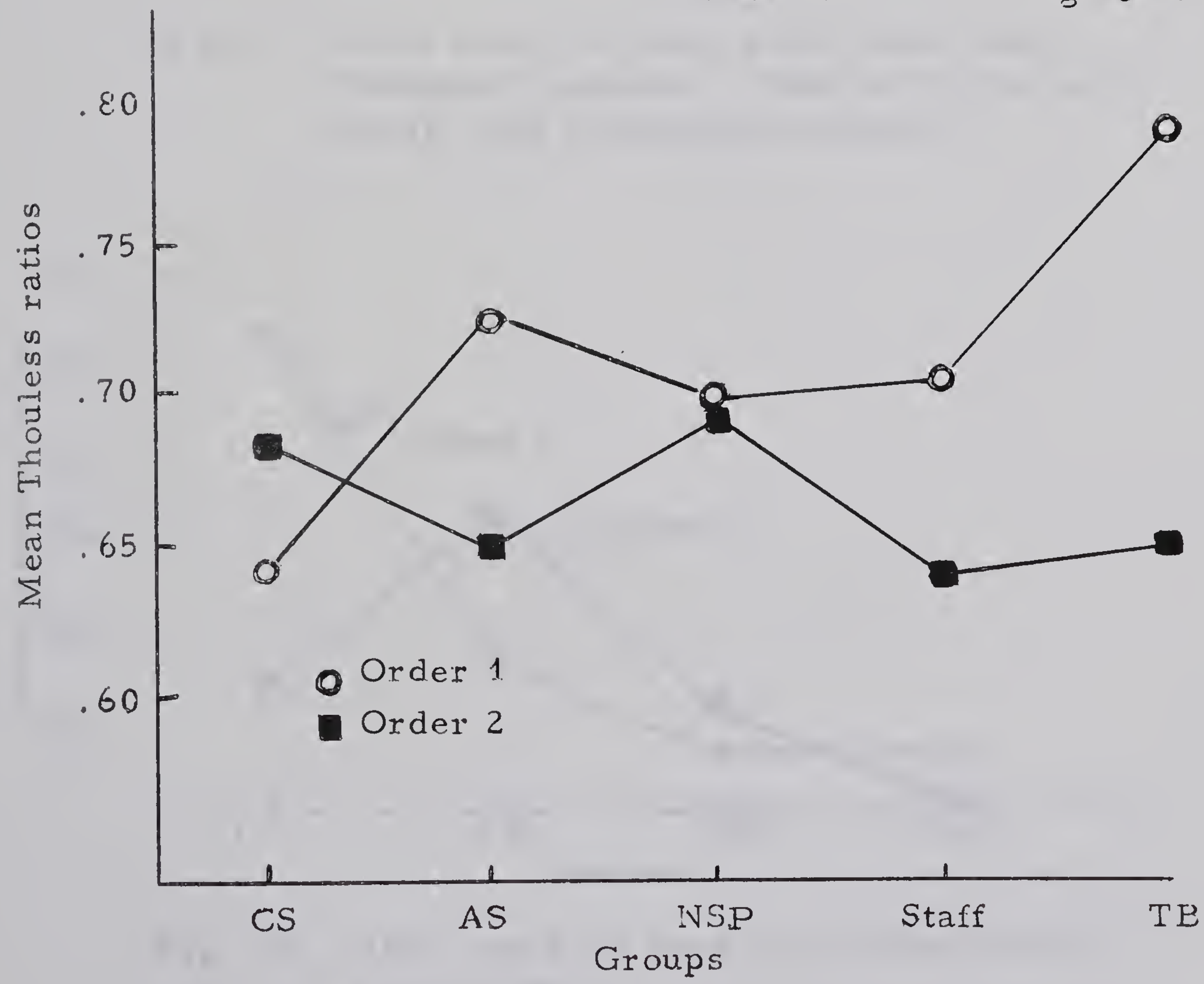


Fig. 8. Mean Thouless ratios for each group under order 1 and order 2.

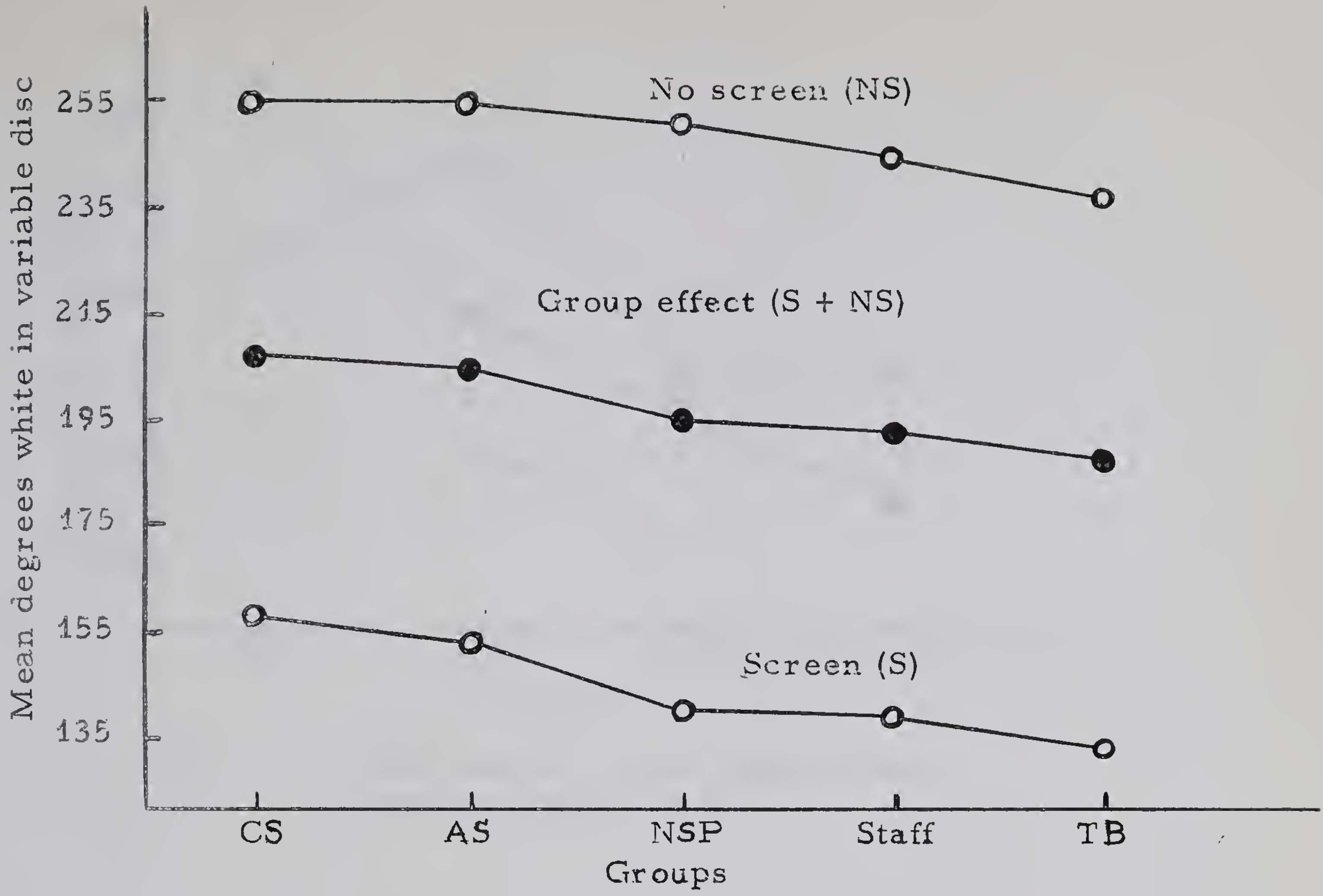


Fig. 9. Mean score for each group under each treatment condition. Mean score for each group, with treatments combined.

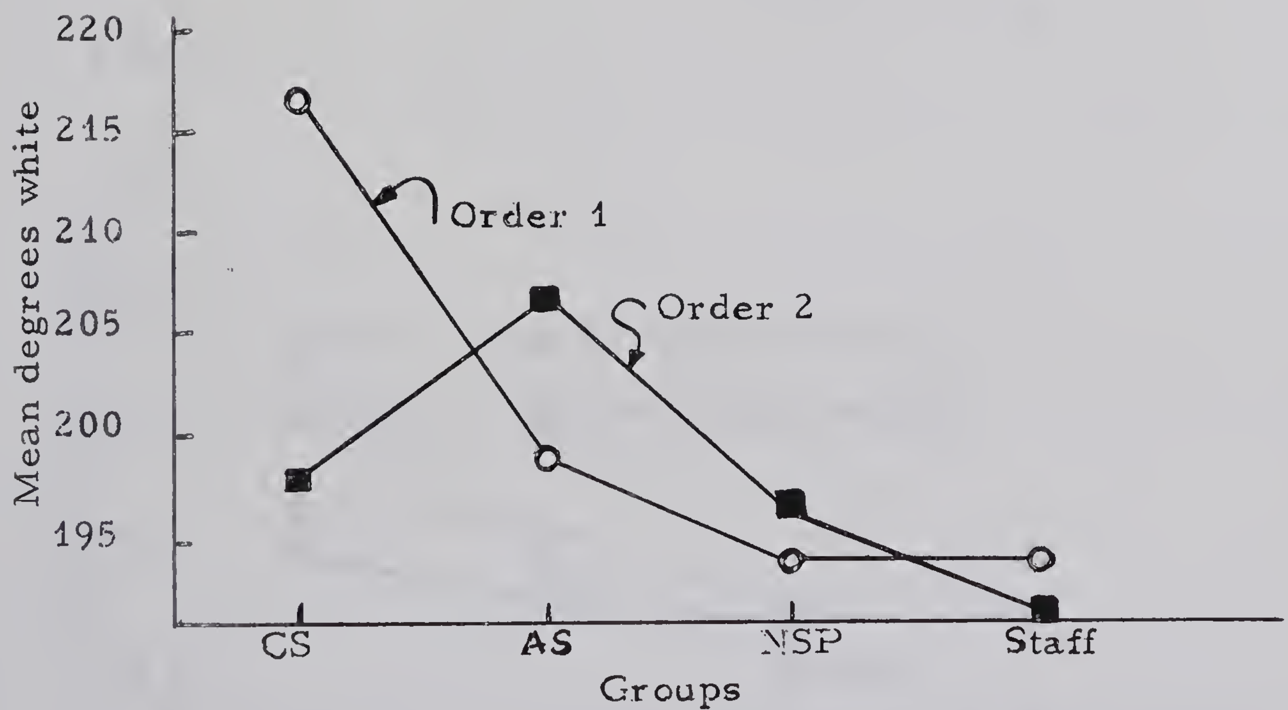


Fig. 10. Mean score for each group under order 1 and order 2.

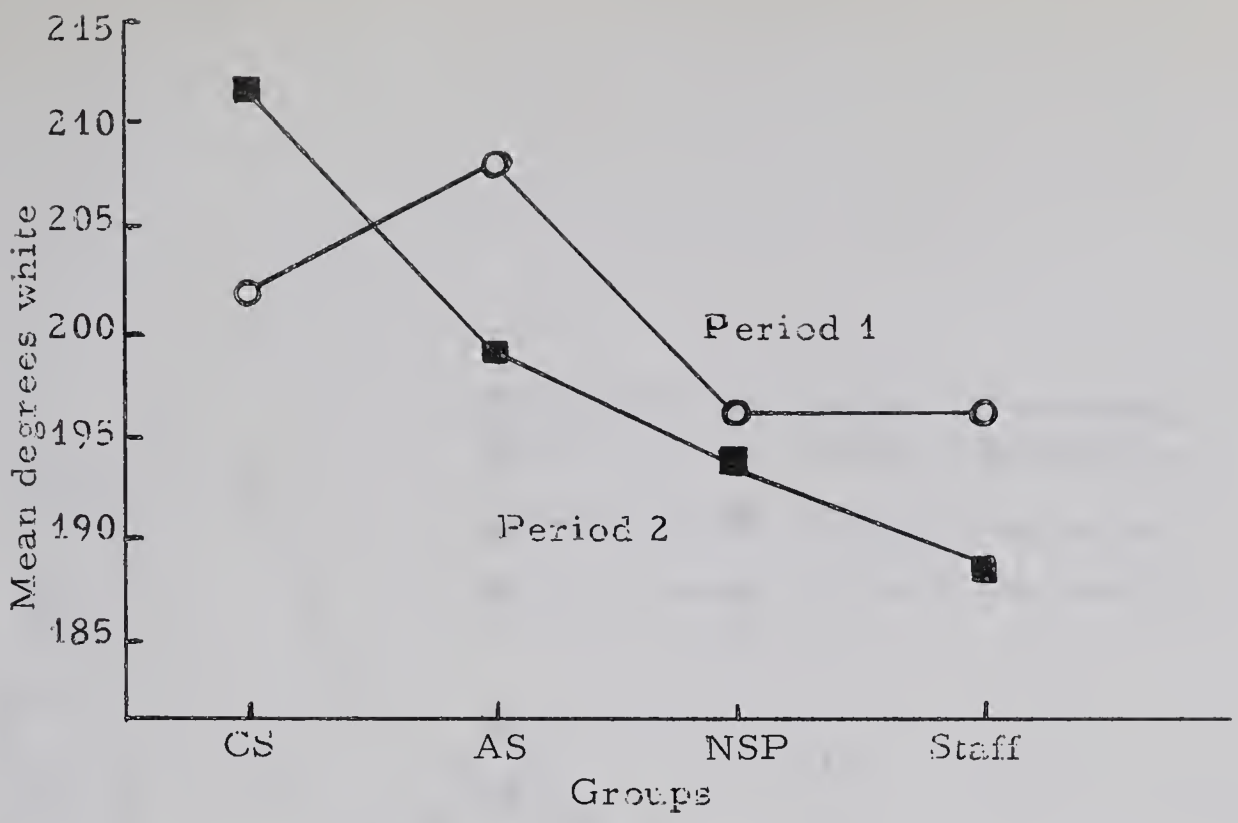


Fig. 11. Mean score for each group under period 1 and period 2.

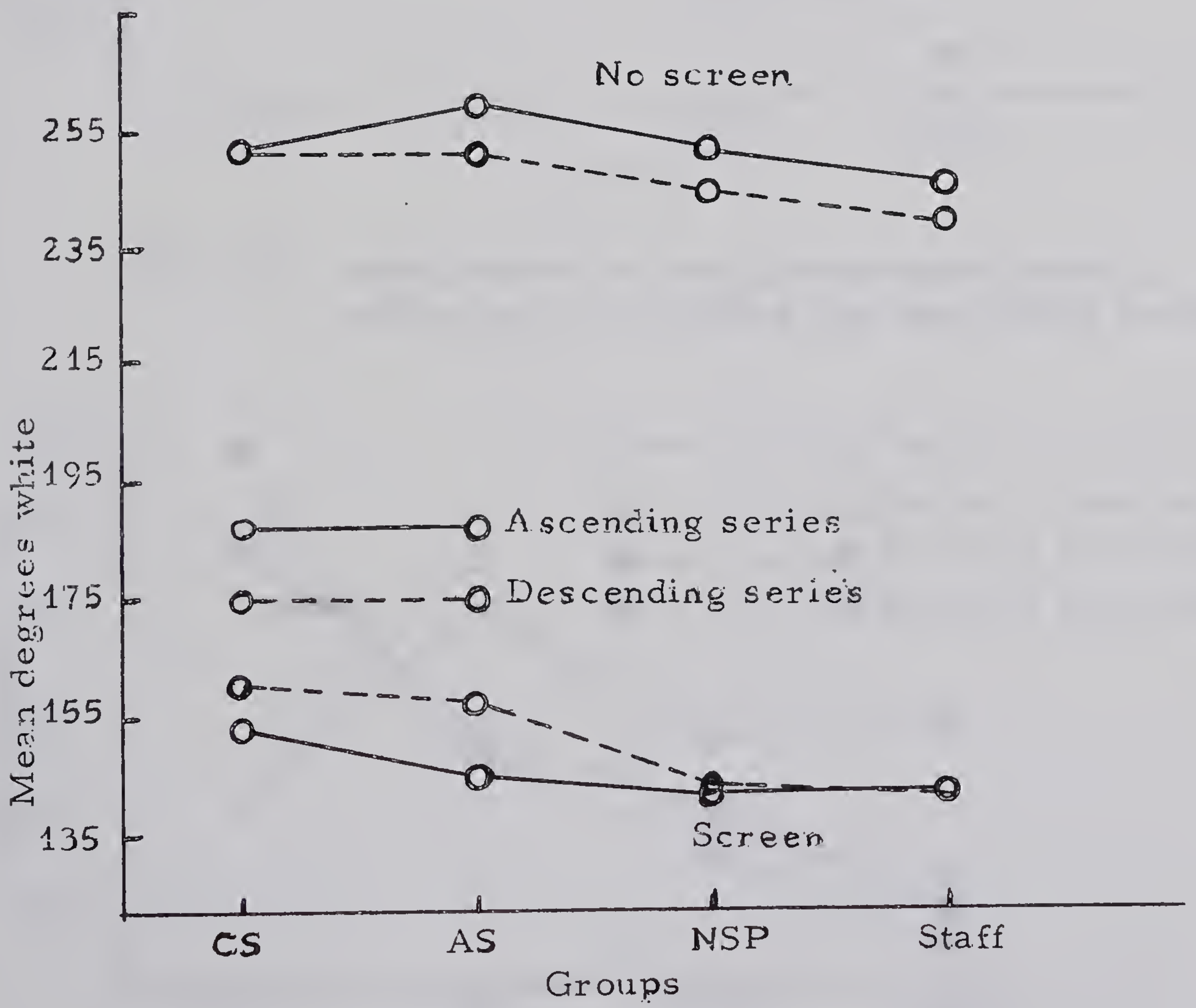


Fig. 12. Mean score for each group under each treatment - .ascending and descending series.

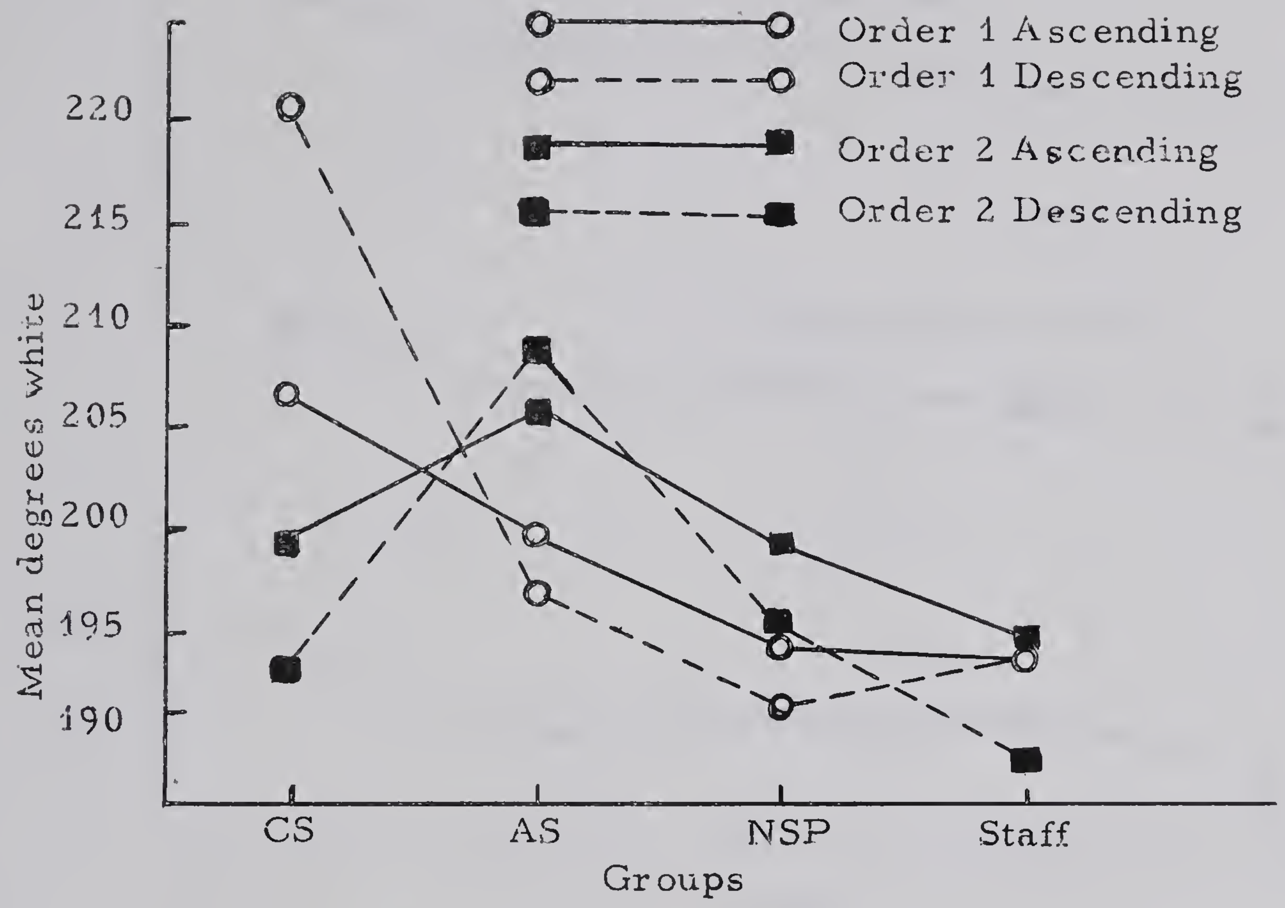


Fig. 13. **Mean score for each group under order 1 and order 2, ascending and descending series.**

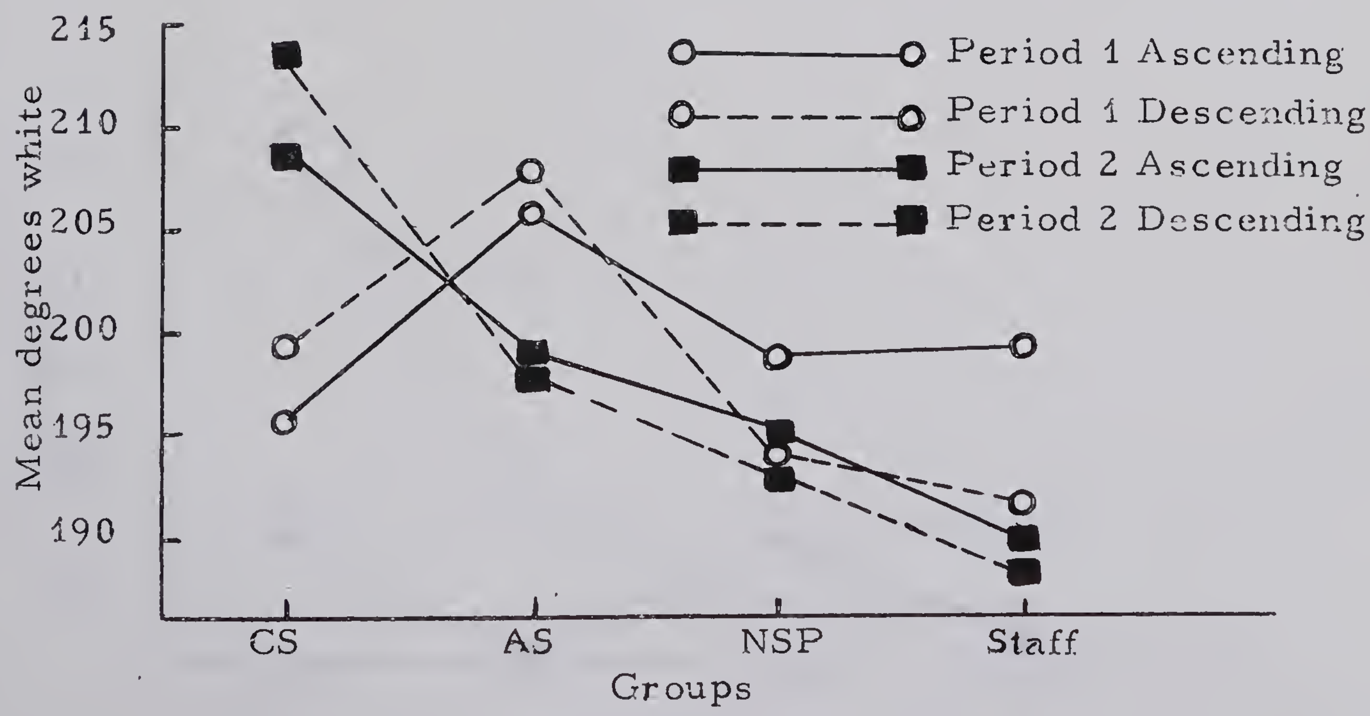


Fig. 14. Mean score for each group under period 1 and period 2. Ascending and descending series.

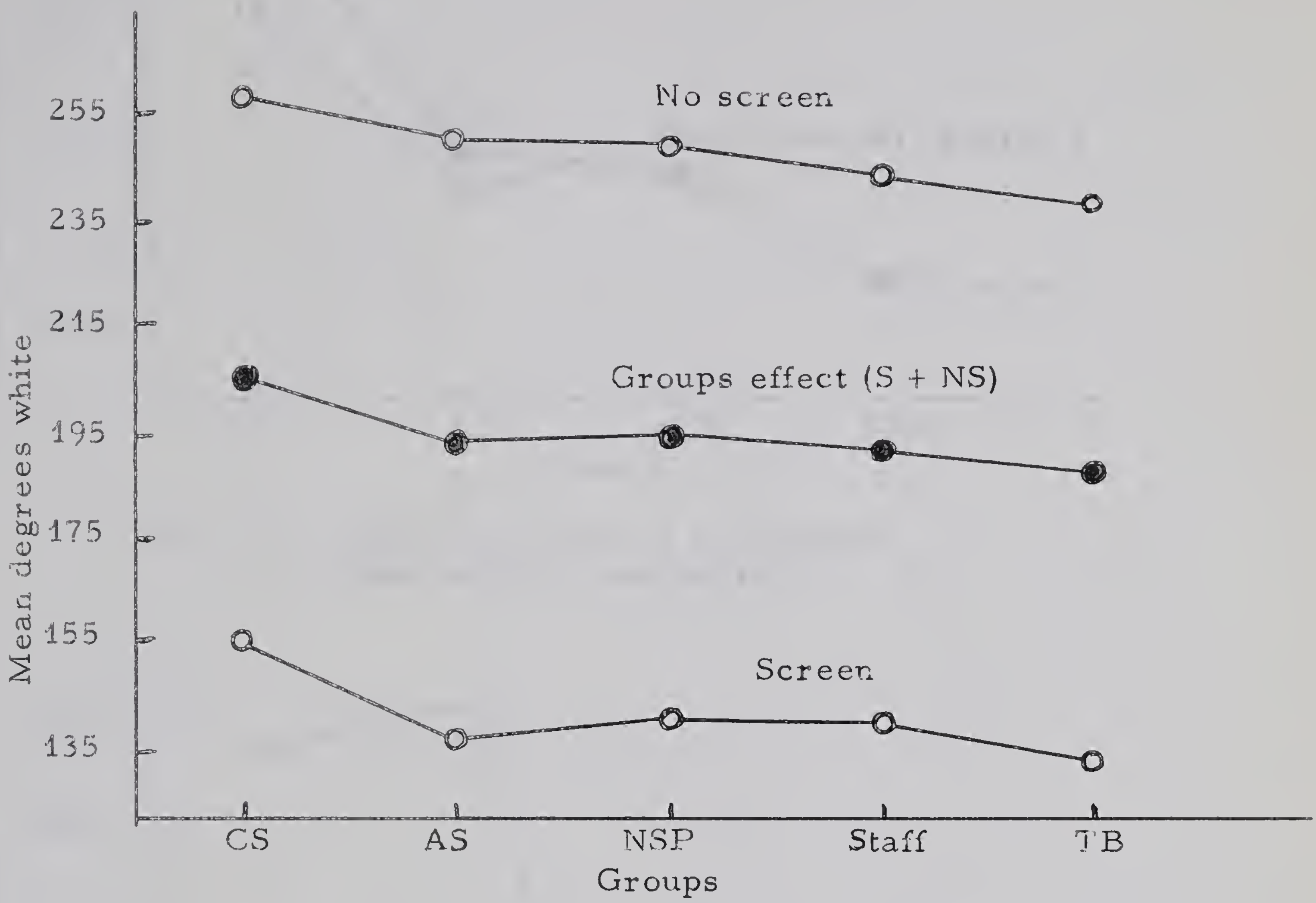


Fig. 15. Adjusted means for each group under screen and no-screen conditions.

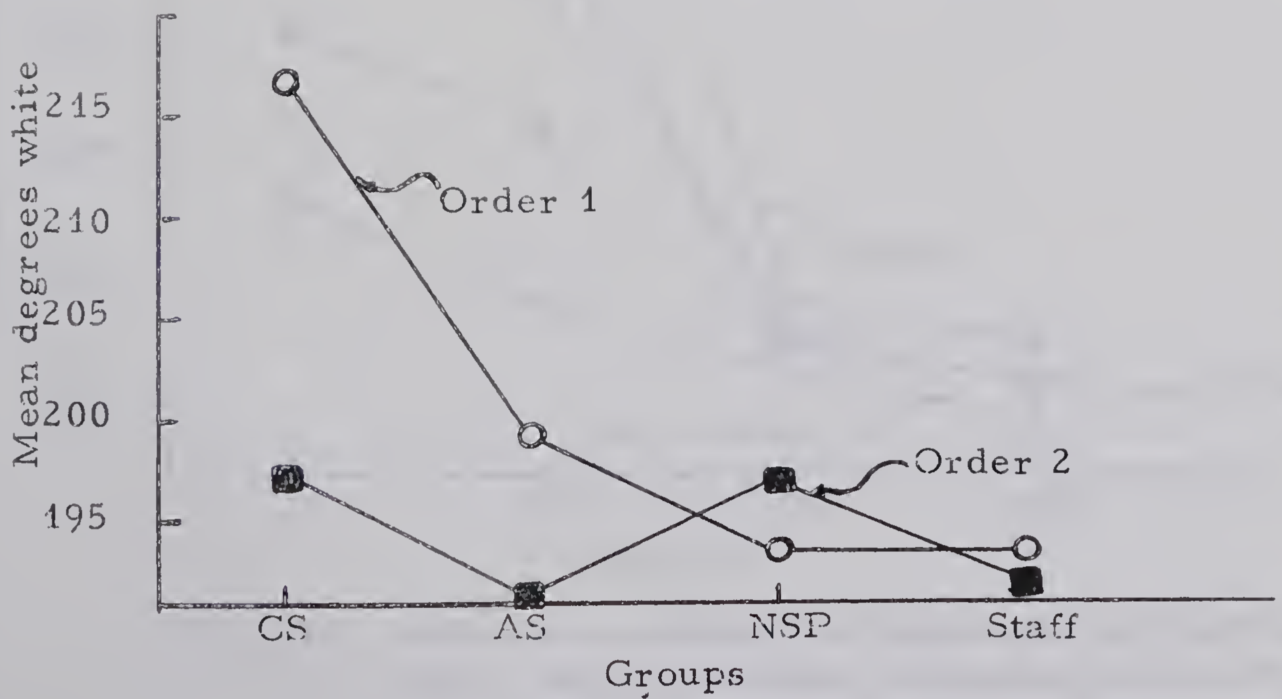


Fig. 16. Adjusted means for each group under order 1 and order 2.

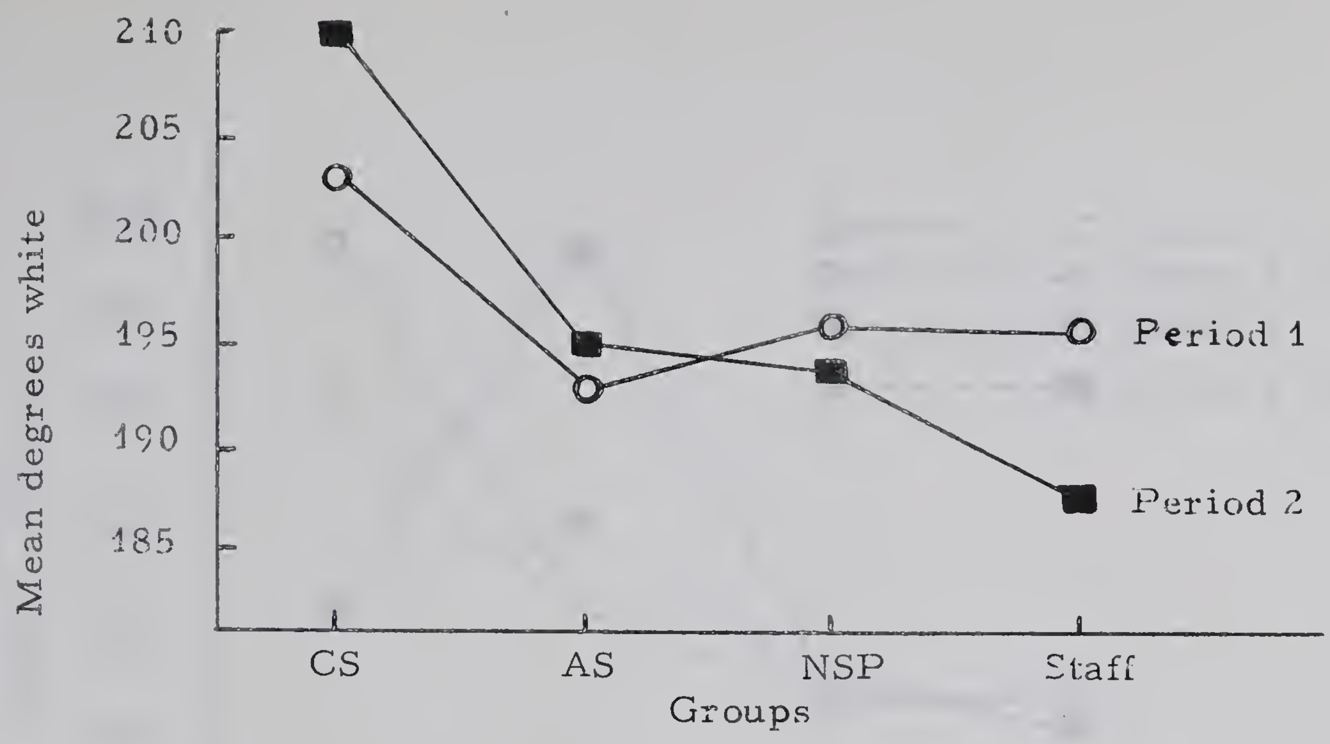


Fig. 17. Adjusted means for each group under period 1 and period 2.

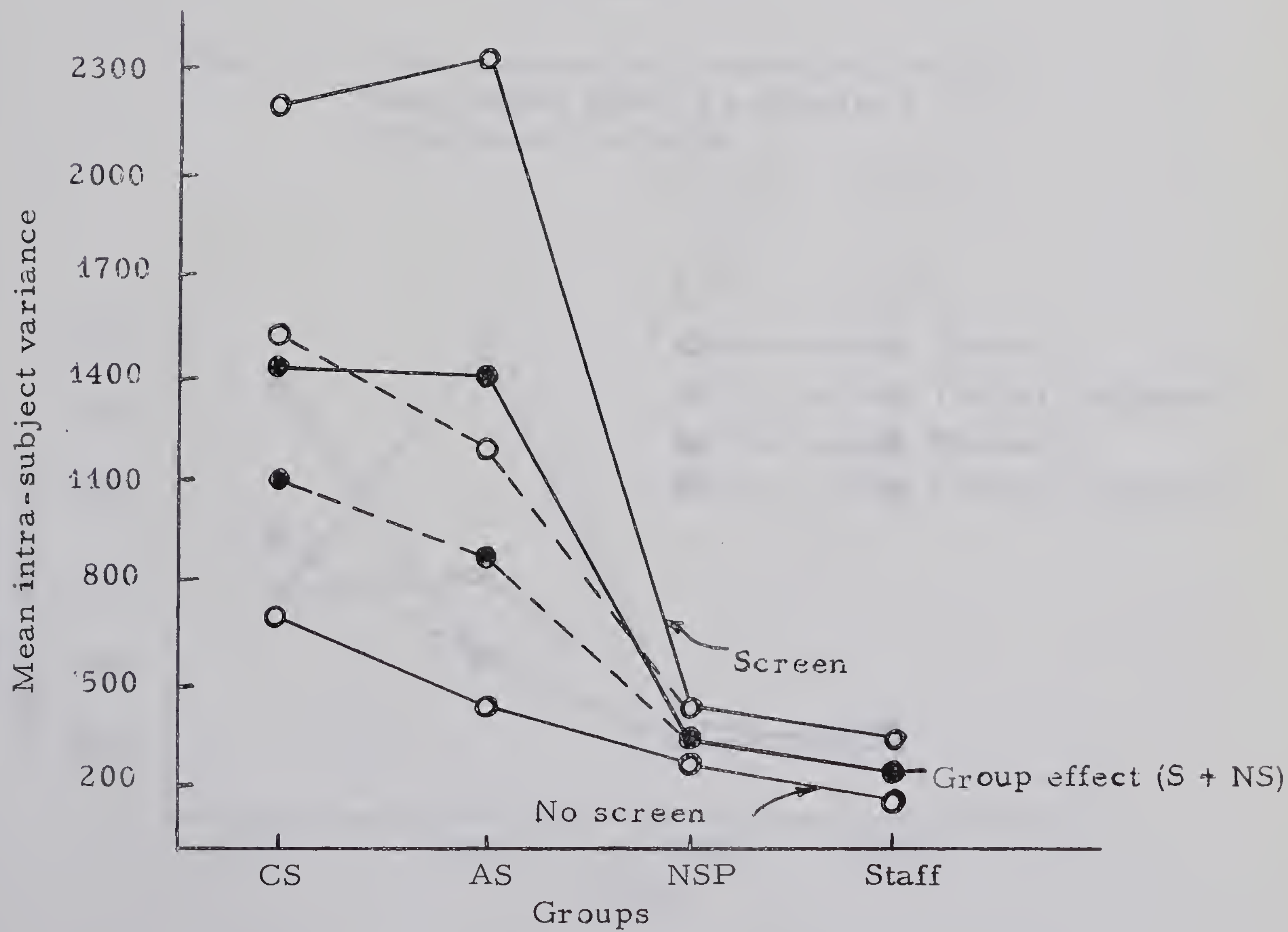


Fig. 18. Mean intra-subject variances for each group under each treatment. Adjusted means are also included and represented by dotted lines.

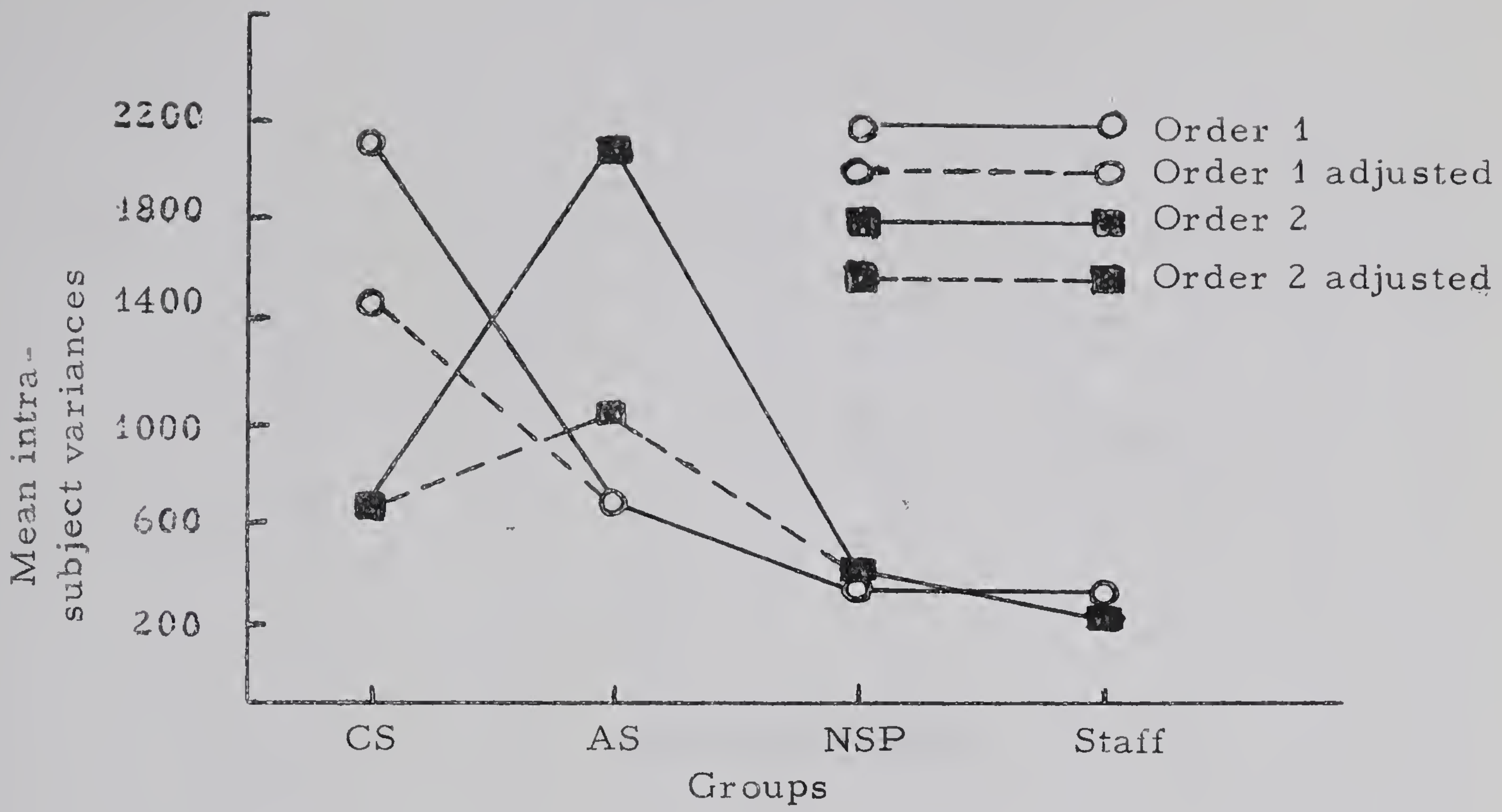


Fig. 19. Mean intra-subject variances for each Group under order 1 and order 2. Adjustments included.

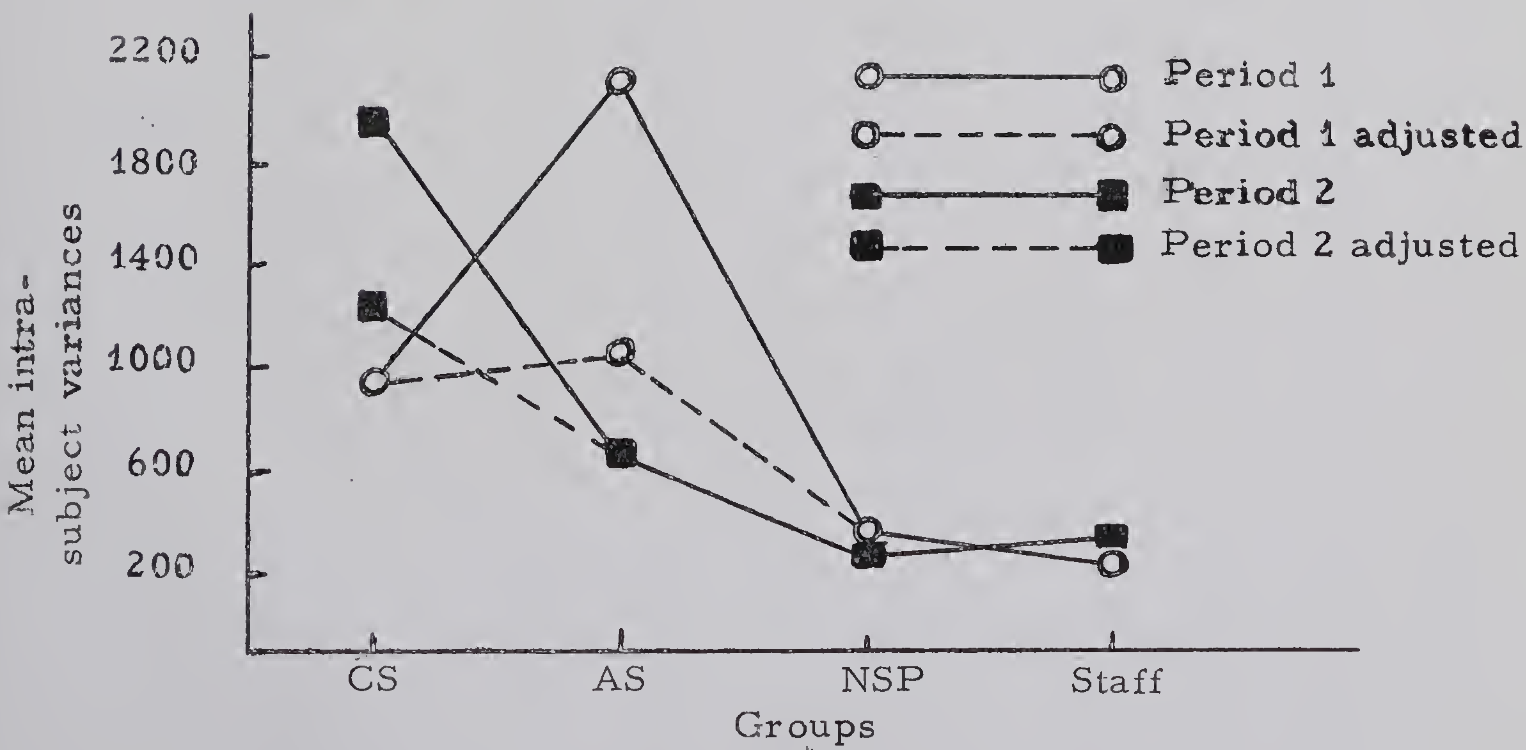


Fig. 20. Mean intra-subject variances for each Group under period 1 and period 2. Adjustments included.

# APPENDICES

# APPENDIX A

## Raw Data

| | Subjects* | No Screen | | | | Screen | | | |
|---|---|---|---|---|---|---|---|---|---|
| | CS11 | 233 | 250 | 290 | 200 | 290 | 104 | 90 | 226 |
| | CS12 | 220 | 179 | 240 | 202 | 210 | 172 | 101 | 260 |
| | CS13 | 300 | 276 | 280 | 289 | 240 | 128 | 240 | 142 |
| | CS14 | 266 | 260 | 266 | 288 | 205 | 160 | 220 | 180 |
| | CS15 | 290 | 310 | 312 | 290 | 128 | 150 | 128 | 115 |
| | CS16 | 225 | 260 | 285 | 262 | 60 | 197 | 170 | 60 |
| | CS17 | 264 | 298 | 288 | 318 | 180 | 240 | 125 | 100 |
| Order | CS18 | 195 | 200 | 285 | 193 | 325 | 95 | 110 | 240 |
| 1 | CS19 | 332 | 288 | 265 | 285 | 240 | 285 | 155 | 170 |
| | CS110 | 295 | 330 | 268 | 285 | 265 | 153 | 220 | 153 |
| | CS111 | 220 | 188 | 272 | 240 | 245 | 175 | 290 | 170 |
| | CS112 | 242 | 292 | 270 | 292 | 202 | 158 | 143 | 162 |
| | CS113 | 242 | 202 | 202 | 205 | 150 | 166 | 175 | 172 |
| | CS114 | 290 | 270 | 235 | 250 | 145 | 145 | 128 | 190 |
| | CS115 | 190 | 226 | 245 | 337 | 160 | 122 | 148 | 155 |
| | CS21 | 260 | 265 | 240 | 285 | 143 | 225 | 193 | 153 |
| | CS22 | 270 | 290 | 242 | 290 | 60 | 92 | 60 | 118 |
| | CS23 | 242 | 221 | 215 | 208 | 110 | 196 | 171 | 245 |
| | CS24 | 280 | 280 | 250 | 268 | 90 | 132 | 75 | 120 |
| | CS25 | 259 | 302 | 304 | 295 | 143 | 130 | 123 | 153 |
| | CS26 | 270 | 249 | 232 | 228 | 129 | 142 | 151 | 150 |
| | CS27 | 244 | 242 | 260 | 251 | 149 | 145 | 100 | 99 |
| Order | CS28 | 258 | 284 | 241 | 248 | 145 | 134 | 129 | 132 |
| 2 | CS29 | 262 | 200 | 283 | 180 | 190 | 225 | 175 | 170 |
| | CS210 | 265 | 270 | 265 | 290 | 265 | 108 | 195 | 205 |
| | CS211 | 245 | 258 | 265 | 265 | 138 | 108 | 138 | 110 |
| | CS212 | 170 | 235 | 225 | 238 | 131 | 155 | 145 | 110 |
| | CS213 | 262 | 300 | 225 | 292 | 150 | 204 | 155 | 171 |
| | CS214 | 228 | 240 | 208 | 240 | 100 | 100 | 90 | 110 |
| | CS215 | 220 | 220 | 220 | 205 | 195 | 210 | 121 | 150 |
| | AS11 | 279 | 263 | 255 | 260 | 105 | 190 | 138 | 121 |
| | AS12 | 280 | 289 | 275 | 263 | 179 | 148 | 115 | 150 |
| | AS13 | 245 | 260 | 268 | 242 | 120 | 130 | 131 | 135 |
| | AS14 | 261 | 274 | 271 | 261 | 201 | 120 | 145 | 140 |
| Order | AS15 | 280 | 261 | 260 | 262 | 148 | 170 | 128 | 128 |
| 1 | AS16 | 281 | 308 | 278 | 305 | 170 | 175 | 145 | 158 |
| | AS17 | 230 | 265 | 258 | 252 | 181 | 89 | 210 | 100 |
| | AS18 | 246 | 270 | 245 | 269 | 220 | 159 | 174 | 139 |

APPENDIX A (cont.)

| | | No Screen | | | | Screen | | | |
|---|---|---|---|---|---|---|---|---|---|
| | AS19 | 215 | 242 | 240 | 288 | 170 | 78 | 135 | 112 |
| | AS110 | 238 | 265 | 240 | 232 | 101 | 150 | 144 | 140 |
| Order | AS111 | 214 | 253 | 337 | 337 | 138 | 132 | 91 | 150 |
| 1 | AS112 | 242 | 250 | 242 | 245 | 110 | 160 | 131 | 112 |
| | AS113 | 195 | 240 | 241 | 225 | 170 | 158 | 125 | 154 |
| | AS114 | 235 | 242 | 219 | 220 | 121 | 111 | 146 | 133 |
| | AS115 | 212 | 215 | 240 | 238 | 150 | 155 | 147 | 170 |
| | AS21 | 255 | 255 | 261 | 290 | 330 | 60 | 288 | 110 |
| | AS22 | 243 | 248 | 239 | 290 | 131 | 163 | 110 | 135 |
| | AS23 | 202 | 199 | 200 | 223 | 105 | 111 | 105 | 110 |
| | AS24 | 270 | 280 | 260 | 268 | 130 | 105 | 190 | 160 |
| | AS25 | 221 | 170 | 282 | 220 | 140 | 151 | 140 | 140 |
| | AS26 | 252 | 268 | 289 | 285 | 100 | 90 | 220 | 290 |
| | AS27 | 265 | 310 | 286 | 310 | 116 | 80 | 125 | 202 |
| Order | AS28 | 225 | 309 | 240 | 256 | 225 | 200 | 240 | 200 |
| 2 | AS29 | 246 | 250 | 247 | 262 | 200 | 240 | 285 | 268 |
| | AS210 | 288 | 285 | 305 | 337 | 320 | 115 | 300 | 65 |
| | AS211 | 241 | 245 | 230 | 231 | 94 | 200 | 122 | 80 |
| | AS212 | 225 | 242 | 230 | 241 | 110 | 120 | 110 | 148 |
| | AS213 | 220 | 224 | 261 | 212 | 120 | 115 | 100 | 118 |
| | AS214 | 260 | 262 | 243 | 270 | 100 | 131 | 150 | 99 |
| | AS215 | 247 | 268 | 269 | 265 | 148 | 222 | 191 | 310 |
| | NSP11 | 238 | 280 | 251 | 255 | 192 | 144 | 116 | 177 |
| | NSP12 | 248 | 278 | 273 | 275 | 190 | 190 | 170 | 142 |
| | NSP13 | 230 | 218 | 237 | 235 | 148 | 175 | 169 | 153 |
| | NSP14 | 220 | 251 | 261 | 239 | 192 | 140 | 148 | 160 |
| | NSP15 | 195 | 230 | 228 | 238 | 158 | 150 | 121 | 110 |
| | NSP16 | 222 | 232 | 228 | 230 | 115 | 145 | 120 | 99 |
| | NSP17 | 205 | 238 | 225 | 251 | 132 | 78 | 100 | 91 |
| Order | NSP18 | 220 | 244 | 262 | 241 | 149 | 128 | 131 | 130 |
| 1 | NSP19 | 265 | 286 | 305 | 305 | 138 | 130 | 130 | 128 |
| | NSP110 | 202 | 258 | 229 | 226 | 102 | 128 | 80 | 130 |
| | NSP111 | 270 | 255 | 270 | 252 | 171 | 148 | 130 | 155 |
| | NSP112 | 269 | 291 | 268 | 269 | 160 | 155 | 124 | 140 |
| | NSP113 | 235 | 210 | 272 | 240 | 115 | 93 | 90 | 118 |
| | NSP114 | 219 | 241 | 250 | 220 | 135 | 136 | 140 | 123 |
| | NSP115 | 245 | 282 | 250 | 270 | 155 | 170 | 131 | 165 |

[illegible]

APPENDIX A (cont.)

| | | No Screen | | | | Screen | | | |
|---|---|---|---|---|---|---|---|---|---|
| | NSP21 | 272 | 244 | 265 | 287 | 162 | 142 | 138 | 158 |
| | NSP22 | 260 | 241 | 245 | 266 | 129 | 130 | 115 | 121 |
| | NSP23 | 240 | 247 | 240 | 241 | 145 | 147 | 131 | 148 |
| | NSP24 | 238 | 242 | 241 | 241 | 110 | 110 | 100 | 100 |
| | NSP25 | 220 | 218 | 218 | 240 | 121 | 129 | 125 | 155 |
| | NSP26 | 233 | 258 | 240 | 240 | 142 | 172 | 114 | 140 |
| | NSP27 | 241 | 240 | 235 | 260 | 125 | 125 | 122 | 150 |
| Order | NSP28 | 241 | 225 | 246 | 256 | 120 | 220 | 150 | 120 |
| 2 | NSP29 | 250 | 262 | 262 | 285 | 218 | 152 | 170 | 148 |
| | NSP210 | 266 | 265 | 266 | 264 | 170 | 125 | 148 | 149 |
| | NSP211 | 272 | 236 | 195 | 220 | 170 | 150 | 190 | 140 |
| | NSP212 | 261 | 255 | 221 | 268 | 220 | 180 | 152 | 180 |
| | NSP213 | 220 | 220 | 208 | 200 | 138 | 185 | 150 | 138 |
| | NSP214 | 271 | 285 | 280 | 300 | 210 | 173 | 149 | 164 |
| | NSP215 | 285 | 300 | 279 | 280 | 110 | 100 | 126 | 110 |
| | | | | | | | | | |
| | ST11 | 261 | 262 | 260 | 284 | 151 | 132 | 156 | 146 |
| | ST12 | 245 | 265 | 260 | 250 | 120 | 140 | 141 | 145 |
| | ST13 | 250 | 240 | 270 | 227 | 217 | 110 | 171 | 123 |
| | ST14 | 243 | 262 | 259 | 268 | 125 | 151 | 138 | 170 |
| | ST15 | 240 | 262 | 260 | 263 | 192 | 156 | 120 | 120 |
| | ST16 | 238 | 239 | 215 | 219 | 121 | 138 | 104 | 127 |
| | ST17 | 288 | 275 | 255 | 286 | 145 | 130 | 122 | 178 |
| Order | ST18 | 215 | 220 | 235 | 222 | 185 | 110 | 145 | 130 |
| 1 | ST19 | 220 | 221 | 245 | 215 | 120 | 149 | 145 | 140 |
| | ST110 | 208 | 210 | 230 | 232 | 158 | 132 | 120 | 129 |
| | ST111 | 235 | 260 | 261 | 265 | 95 | 115 | 121 | 126 |
| | ST112 | 265 | 265 | 270 | 263 | 155 | 162 | 132 | 131 |
| | ST113 | 258 | 255 | 250 | 290 | 130 | 128 | 115 | 130 |
| | ST114 | 246 | 244 | 241 | 245 | 118 | 132 | 113 | 130 |
| | ST115 | 220 | 248 | 225 | 270 | 138 | 128 | 128 | 159 |
| | | | | | | | | | |
| | ST21 | 218 | 236 | 233 | 238 | 160 | 161 | 150 | 138 |
| | ST22 | 255 | 288 | 260 | 286 | 125 | 130 | 125 | 151 |
| Order | ST23 | 240 | 252 | 235 | 248 | 133 | 132 | 135 | 165 |
| 2 | ST24 | 240 | 228 | 225 | 220 | 125 | 160 | 161 | 150 |
| | ST25 | 238 | 235 | 239 | 260 | 202 | 161 | 153 | 170 |
| | ST26 | 228 | 240 | 198 | 229 | 128 | 112 | 118 | 129 |
| | ST27 | 225 | 238 | 250 | 228 | 151 | 161 | 134 | 160 |
| | ST28 | 220 | 260 | 220 | 248 | 160 | 162 | 165 | 165 |

APPENDIX A (cont.)

| | | No Screen | | | | Screen | | | |
|---|---|---|---|---|---|---|---|---|---|
| | ST29 | 239 | 262 | 260 | 278 | 148 | 146 | 130 | 146 |
| | ST210 | 245 | 240 | 245 | 269 | 117 | 100 | 100 | 119 |
| Order | ST211 | 210 | 218 | 225 | 202 | 121 | 110 | 103 | 103 |
| 2 | ST212 | 265 | 260 | 265 | 250 | 170 | 242 | 210 | 226 |
| | ST213 | 230 | 200 | 198 | 205 | 160 | 110 | 90 | 118 |
| | ST214 | 200 | 200 | 202 | 220 | 108 | 133 | 110 | 130 |
| | ST215 | 270 | 280 | 246 | 290 | 152 | 175 | 129 | 150 |
| | TB11 | 245 | 265 | 247 | 278 | 125 | 125 | 128 | 147 |
| | TB12 | 212 | 282 | 228 | 267 | 177 | 175 | 172 | 185 |
| | TB13 | 285 | 335 | 340 | 305 | 215 | 90 | 125 | 190 |
| Order | TB14 | 285 | 285 | 215 | 280 | 100 | 130 | 185 | 175 |
| 1 | TB15 | 305 | 290 | 240 | 288 | 125 | 128 | 103 | 150 |
| | TB16 | 230 | 235 | 250 | 245 | 151 | 150 | 126 | 116 |
| | TB17 | 290 | 290 | 295 | 285 | 140 | 140 | 150 | 140 |
| | TB21 | 220 | 192 | 225 | 263 | 103 | 130 | 110 | 135 |
| | TB22 | 238 | 265 | 238 | 250 | 133 | 122 | 122 | 132 |
| Order | TB23 | 220 | 248 | 220 | 248 | 176 | 138 | 198 | 198 |
| 2 | TB24 | 170 | 203 | 200 | 195 | 140 | 105 | 102 | 103 |
| | TB25 | 250 | 245 | 270 | 266 | 115 | 155 | 126 | 160 |
| | TB26 | 270 | 270 | 270 | 268 | 122 | 119 | 126 | 126 |
| | TB27 | 269 | 250 | 270 | 255 | 235 | 150 | 265 | 128 |

* CS - Chronic Schizophrenic Patient

AS - Acute Schizophrenic Patient

NSP - Non-Schizophrenic Patient

ST - Staff

TB - Tuberculous Controls

The first number identifies the order, the last number(s) identify the subject within an order.

[illegible]

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

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## APPENDIX B

Summary of the Analysis of Variance of the Brunswik ratios for both Ascending and Descending series. Means are included.

1. Ascending series

| Source | df | MS | F |
|---|---|---|---|
| Order (A) | 1 | 1386.0 | 3.09 |
| Group (B) | 4 | 266.0 | - |
| A X B | 4 | 229.0 | - |
| Residual | 124 | 448.2 | |
| Total | 133 | | |

2. Descending series

| Source | df | MS | F |
|---|---|---|---|
| Order (A) | 1 | 1197.0 | 3.60 |
| Group (B) | 4 | 273.5 | - |
| A X B | 4 | 257.0 | - |
| Residual | 124 | 332.4 | |
| Total | 133 | | |

3. Mean Brunswik Ratios (Orders combined) for the Ascending and Descending series.

Ascending series

a)

| | | | |
|---|---|---|---|
| CS | .605 | Staff | .580 |
| AS | .595 | TB | .625 |
| NSP | .600 | | |

b) Descending series

| | | | |
|---|---|---|---|
| CS | .55 | Staff | .53 |
| AS | .545 | TB | .57 |
| NSP | .575 | | |

## APPENDIX C

Summary of the Analysis of Variance of the Brunswik Ratios with the Aberrant Cases omitted for both Ascending and Descending series.

Ascending series

1.

| Source | df | MS | F |
|---|---|---|---|
| Order (A) | 1 | 121.0 | - |
| Groups (B) | 4 | 401.0 | 1.25 |
| A X B | 4 | 29.5 | - |
| Residual | 119 | 320.0 | |
| Total | 128 | | |

2. Descending series

| Source | df | MS | F |
|---|---|---|---|
| Order (A) | 1 | 316.0 | 1.17 |
| Groups (B) | 4 | 155.7 | - |
| A X B | 4 | 212.0 | - |
| Residual | 119 | 269.0 | |
| Total | 128 | | |

3. Mean Brunswik Ratios with the Aberrant Cases omitted.

a) Ascending series

| | | | |
|---|---|---|---|
| CS | .67 | Staff | .58 |
| AS | .66 | TB | .625 |
| NSP | .60 | | |

Descending series

| | | | |
|---|---|---|---|
| CS | .565 | Staff | .53 |
| AS | .61 | TB | .57 |
| NSP | .575 | | |

## APPENDIX D

Multiple Comparisons Test on Mean Thouless Ratios

| | | | A | B | C | D | E | Shortest significance range | |
|---|---|---|---|---|---|---|---|---|---|
| | Means | | 66 | 67.5 | 69 | 69.5 | 72 | R2 | 42.4 |
| CS | A | 66 | | 1.5 | 3 | 3.5 | 6 | R3 | 45.4 |
| Staff | B | 67.5 | | | 1.5 | 2 | 4.5 | R4 | 47.0 |
| AS | C | 69 | | | | .5 | 3 | R5 | 48.2 |
| NSP | D | 69.5 | | | | | 2.5 | | |
| TB | E | 72 | | | | | * | | |

* Any two treatment means underscored by the same line are not significantly different.

## APPENDIX E

Summary Analysis of Variance of the Thouless Ratios
Ascending and Descending series Combined
(2 X 4 factorial)

| Source | df | MS | F |
|---|---|---|---|
| Order (A) | 1 | 98.9 | - |
| Groups (B) | 3 | 49.1 | - |
| A X B | 3 | 266.2 | 1.07 |
| Residual | 112 | 248.4 | |
| Total | 119 | | |

## APPENDIX F

1. Summary Analysis of Variance of Arcsin Ratios

| Source | df | MS | F |
|---|---|---|---|
| Order (A) | 1 | 5642.0 | 4.41* |
| Group (B) | 4 | 1399.7 | 1.09 |
| A X B | 4 | 940.0 | - |
| Residual | 124 | 1278.8 | |
| Total | 133 | | |

* < .05

2. Mean Arcsin Ratios (Orders Combined) for each Group

| | | | |
|---|---|---|---|
| CS | .96 | Staff | .96 |
| AS | .98 | TB | .85 |
| NSP | .99 | | |

## APPENDIX G

1. Simple Analysis of Variance of Diagnotic Sub-Groups in the Chronic Schizophrenic Patient Group

| Source | df | MS | F |
|---|---|---|---|
| Between | 4 | 246.7 | .607 |
| Within | 25 | 406.9 | |

2. Mean Brunswik Ratios of Respective Diagnostic Sub-Groups in Schizophrenic Group

| | |
|---|---|
| Catatonic | .51 |
| Hebephrenic | .70 |
| Paranoid | .582 |
| Simple | .60 |
| Undifferentiated | .579 |

## APPENDIX H

1. Mean Score for each Group under Order One and Order Two

| | CS | AS | NSP | Staff |
|---|---|---|---|---|
| Order one | 217 | 199 | 193 | 193 |
| Order two | 198 | 207 | 197 | 191 |

2. Mean Score for each Group under Period One and Period Two

| | CS | AS | NSP | Staff |
|---|---|---|---|---|
| Period one | 202 | 208 | 196 | 196 |
| Period two | 212 | 199 | 194 | 188 |

## APPENDIX I

1. One Way Analysis of No-Screen Matches

| Source | df | MS | F |
|---|---|---|---|
| Between | 4 | 16370 | 1.04 |
| Within | 129 | 15803 | |

2. One Way Analysis of Variance of Screen Matches

| Source | df | MS | F |
|---|---|---|---|
| Between | 4 | 30541 | 2.39* |
| Within | 129 | 12764 | |

* The F value required for significance at the .05 level is 2.44.

## Appendix I (cont.)

3. One Way Analysis of Variance of Group Means with the Aberrant Cases Omitted. Screen Condition.

| Source | df | MS | F |
|---|---|---|---|
| Between | 4 | 1101.0 | 1.90* |
| Within | 121 | 577.6 | |

* The F value required for significance at the 0.1 level is 1.99.

4. One Way Analysis of Variance of Groups, under the No-Screen Condition with Equal Illumination.

| Source | df | MS | F |
|---|---|---|---|
| Between | 4 | 104 | .93 |
| Within | 129 | 112 | |

## APPENDIX J

1. The Mean Scores for each Group under each Treatment Condition for both Ascending and Descending series.

Ascending series

| | CS | AS | NSP | Staff |
|---|---|---|---|---|
| No-screen | 252 | 259 | 252 | 247 |
| Screen | 154 | 145 | 141 | 142 |

Descending series

| | CS | AS | NSP | Staff |
|---|---|---|---|---|
| No-screen | 253 | 249 | 245 | 240 |
| Screen | 160 | 157 | 242 | 140 |

Appendix J (cont.)

2. The Mean Score for each Group under Order One and Order Two for both the Ascending and Descending series.

Ascending series

| | CS | AS | NSP | Staff |
|---|---|---|---|---|
| Order one | 207 | 199 | 194 | 193 |
| Order two | 199 | 206 | 199 | 195 |

Descending series

| | CS | AS | NSP | Staff |
|---|---|---|---|---|
| Order one | 221 | 197 | 190 | 193 |
| Order two | 193 | 209 | 196 | 187 |

3. The Mean for each Group under Period One and Period Two for both the Ascending and Descending series.

Ascending series

| | CS | AS | NSP | Staff |
|---|---|---|---|---|
| Period one | 196 | 206 | 198 | 199 |
| Period two | 209 | 199 | 195 | 190 |

Descending series

| | CS | AS | NSP | Staff |
|---|---|---|---|---|
| Period one | 199 | 208 | 194 | 192 |
| Period two | 214 | 198 | 193 | 188 |

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|---|---|---|---|---|
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| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

## APPENDIX K

1. Adjusted Means for each Group under Order One and Order Two

| | CS | AS | NSP | Staff |
|---|---|---|---|---|
| Order one | 217 | 199 | 193 | 193 |
| Order two | 197 | 190 | 197 | 191 |

2. Adjusted Means for each Group under Period One and Period Two

| | CS | AS | NSP | Staff |
|---|---|---|---|---|
| Period one | 203 | 193 | 196 | 196 |
| Period two | 210 | 195 | 194 | 188 |